The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

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The Road to Results

"GENIUS means an infinite capacity for taking pains," remarked Ellice Hopkins. This maxim while true on the day it was uttered is more so today, and in coming years will be of even greater significance. Individual competition was not so acute in bygone days but with the passing of each year any distinction of note is rendered more difficult of attainment.

While the author speaks of Genius as attainable in the manner mentioned, it is equally true that most worth while accomplishments are the result of the same endowment.

It was "an infinite capacity for taking pains," by various scientists, that enabled Elbert H. Gary, by passing his hand over a silver-lined sphere in New York, to put in motion the new rolling mills at the Homestead plant of the Carnegie Steel Company.

Similarly, extensive experiments and intense research, by the organization of a large steel company, revealed certain principles concerning the rolling of sheets, which, when incorporated in appropriate machinery permitted the construction of the first successful continuous sheet mill.

In the initial stages of the development of many processes improvements are comparatively easily discerned, but as such processes approach perfection betterments become less obvious. It is then that the "infinite capacity for taking pains" is a requisite for further advancement and the full import of Hopkins' maxim is impressed upon us.

New Steel Plant of the Timken Company

Steel Melted in Both Electric and Open Hearth Furnaces. Charging Machine and Ladle Crane of Improved Design. Plant Arranged for Economical Operation

THE policy of assuming full control over the character of the raw materials entering into its product, which is becoming more common with large manufacturers, led the Timken Roller Bearing Company sometime ago to the establishment of a complete plant for the production and fabrication of its own steel. Comparatively recently the necessity became evident for the enlargement of these facilities, partly because of the rapid increase in the volume of the company's own production, and partly because of a belief, which has been borne out by results, that a considerable demand for a supply of especially high grade steel existed among other manufacturers of different products who, for various reasons, found it impractical to make or difficult to procure in bulk. As a consequence, a new mill was built, and has just gone into operation, which has been planned on the basis of a tonnage capacity sufficient to meet both of these needs for some time to come. Aside from being what is practically the most completely electrified mill in the country, it contains several other innovations in the way of equipment which make it of considerable interest.

The new plant comprises two buildings, one of which houses the furnaces, and the charging and ladle handling apparatus. Among the latter are two especially noteworthy features, which will be described later in detail. One is the first ladle crane to be equipped with worm drive, and the other a new type of worm driven charger. The other building contains the soaking pits, rolling mill, shear, and annealing pits, together with the necessary apparatus for handling the ingots and blooms. Adjoining the furnace house is a large shed for the storage of scrap to supply the furnaces, handling into and out of cars being accomplished by means of magnet cranes. The two buildings are connected with each other, and with the rest of the plant, by a complete system of broad and narrow gauge tracks, suitable for use either by steam or by gasolene locomotives.

Building Layout

The entire layout of the furnace building has been planned with the idea of increasing to the utmost the speed and convenience of all the operations connected with the production of the steel. The building is divided longitudinally into two sections, the charging floor, and the pouring floor, each of which occupy about half its width. The former really consists of a platform, raised about 17 ft. above the level of the pouring floor, on which are located the charger which serves the open-hearth furnace and the electric furnaces, the transformers which supply power to the electric furnaces, and the offices. The furnaces, which include two 15-ton and one 7-ton 3-phase electric arc furnaces, and one 100-ton open hearth, are supported on separate foundations, which bring them up to the level of the charging floor. This construction is shown in Fig. 1. By virtue of this arrangement, slag pits for the furnaces are dispensed with, and the charging floor left free for charging operations. The motor-driven tilting mechanisms for the electric furnaces are located directly back of the individual furnace foundations, the control being on the platform above. Thus, not only is the charging floor free from encumberances, and obstacles, but the pouring floor is equally free, so that ladles can be moved quickly wherever desired, without requiring constant manipulation on the part of the crane operator to avoid other apparatus and equipment.

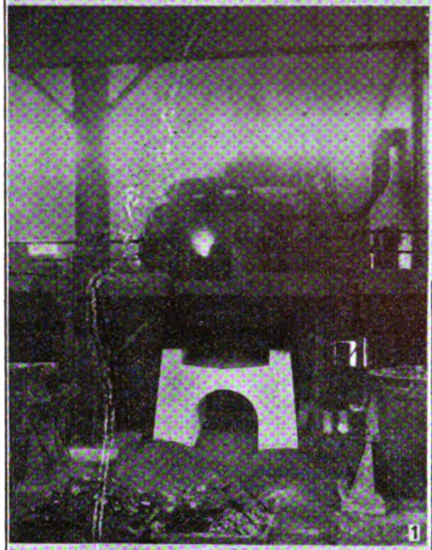
Power to operate the electric furnaces comes in at 22,000 volts, and is stepped down to the operating voltage of 140-250 by two 7,500 kva. and one 3,000 kva, 3-phase water-cooled furnace transformers. The transformers are housed in individual brick compartments located alongside of the particular furnace they supply. The automatic electric control for the furnaces is installed in recesses which have been provided in the outside wall of the transformer compartments. This arrangement is shown in Fig. 2. Electric furnaces have been chosen because their close, automatic regulation, and the absence of oxidizing agents in the furnace atmosphere, insures the exact duplication, both as to analysis and general quality, of the steel produced by every heat.

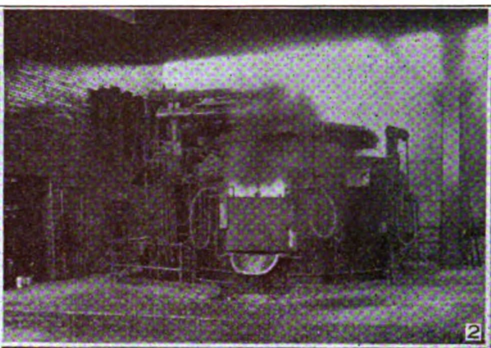
New Type Charging Machine

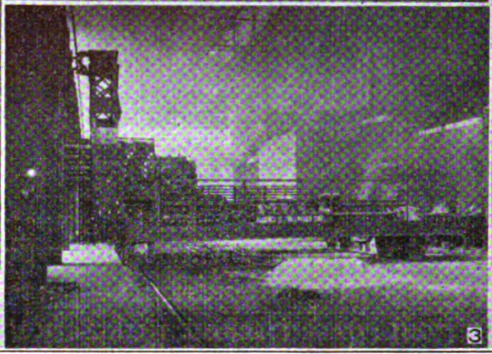
Both the electric furnaces and the open-hearth furnace is served by a new variety of charger which is one of the features of the installation. This machine, a low floor type of 5-ton capacity, is not only the first of its kind to be equipped with worm gear drive, but is the first to be supplied throughout with standard Timken tapered roller bearings. The construction and operation of the machine are, briefly, as follows: The trolley frame and end casting are both solid, one piece castings—the former weighing 36,000 lbs. before it was machined. This construction eliminates the necessity for mounting the driving motors and shafts on separate supports bolted to the frame, which are liable to work loose as a result of the severe racking and vibration to which the machine as a whole is subject, and throw the assembly out of alignment. The charging ram is of forged steel, this material being more resistant to heat than cast steel, and consequently having a longer life. The ram is raised and lowered by means of two crank shafts which are driven by a 40-hp. motor through a worm gear having a speed reduction ratio of 20:1. The shafts of both the worm and wheel respectively of the gear are equipped with three sets of tapered roller bearings, the two inboard bearings being of the single, and the outboard, or pinion bearing being of the double type. The ram is rotated by a 5-hp. motor which drives it through a set of spur gears.

The trolley cross travel mechanism is driven through a worm gear by a 30-hp. motor located at right angles to the direction of travel. In this case also both the worm and wheel shafts of the train run on tapered roller bearings, the arrangement for both being the same as that for the hoist gear. Bridge travel is obtained by two 40-hp. motors, one on each side of the bridge, each of which drives its own set of track wheels through a geared line shaft. The shaft, and all the wheels are completely equipped with tapered roller bearings. The entire control is of the magnetic time limit variety.

Several striking advantages have been claimed for this machine, the more important of which are, briefly, as follows: In the first place, the substitution of worm for spur gears rendered the machine much simpler, and therefore easier both to operate and maintain. Secondly, both the number of moving parts, and the friction load imposed by those actually incorporated in the machine have been greatly reduced, which has in turn made it possible to use motors of a lower horse power, with a consequent saving in power consumption. Also the combination of worm drive, and the liberal use of tapered roller bearings have minimized the lubrication expense, besides making the machine much easier running, and thereby lengthening its useful life. Last, but not least, a construction has been permitted that gives the operator an unobstructed view of the end of the ram, the charge, the floor and the interior of the furnace.







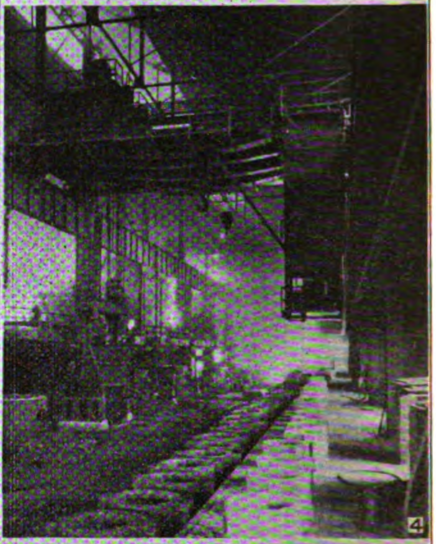


FIG. 1—View of the charging floor from the pouring floor, showing method of supporting the furnaces. FIG. 2—One of the electric furnaces, showing the location of the transformer compartment, and method of mounting the furnace control. FIG. 3—The 5-ton worm driven charger. FIG. 4—View of the 165-ton ladle crane taken from the pouring floor.

Ladle Crane of New Design

On the pouring side of the building, the most interesting piece of apparatus is the 165-ton ladle crane, which is also the first of its type to be equipped with worm gear drive and to have tapered roller bearings throughout. A good idea of its size and construction can be obtained from Fig. 4. The crane is of the four girder type, and, in addition to the 165 ton main hoist, is equipped with a 50-ton auxiliary trolley, and a 15-ton auxiliary hoist. A novel arrangement has been developed for the drive of the main hoist, which, in addition to simplifying its operation and construction, adds considerably to its safety features. The main hoist drive shaft consists of two sections of equal length butted together, and connected by a flexible coupling. Each section has a 110-hp. driving motor at the far end, which is connected through a flexible coupling to a worm gear, which drives one of the hoisting drums through a pinion mounted on the shaft of the worm wheel. A solenoid brake is mounted on each section, between the worm gear and the main coupling in the center. The effect therefore is that of a continuous shaft with a driving motor, gears, and brakes at each end. The two hoisting drums are so located that their driving gears are parallel, and while under normal conditions they do not make contact, in case of failure of a drum pinion, shaft or worm gear on either end of the main shaft they will make contact, so that the solenoid brake on the section of the shaft that is still operative can hold both drums stationary, and prevent the load from dropping.

In this case, as in that of the charger, the two elements of the worm gears are mounted on tapered roller bearings, the arrangement being the same as that described on the charger. The rest of the drives on the crane are of the spur gear variety, the trolley being driven by a 40-hp. motor through two sets of gears, and the bridge travel mechanism by two 90-hp. motors. The bridge has double compensating trucks, with a total of eight wheels at each end, two of which are driving wheels. All the motions are completely equipped with tapered roller bearings, there being a total of 342 being used.

The advantages claimed for the combination of tapered roller bearings and worm drive on the crane are the same as regards simplicity, ease of operation and saving in lubrication and maintenance expense as those for the charger. There is however, an additional advantage in that, in the ease of worm drive, no ratchets, or ratchet equalizing gears are required.

(Continued on page 325)

The Operation of Large Hearth Furnaces Using Coke Made from One Hundred Per Cent High Volatile Coal*

Coke from Mixed Coal Gives Greater Production of Iron—Size of Coke Charged Controls Combustibility—Effect of Composition of Coke, and Interior Furnace Lines, on Operation

By JAMES E. LOSE†

PART II

THE quantity of iron possible to produce from a given furnace is dependent upon the chemical and physical properties of all raw materials used. The main properties of the raw materials which affect this feature of operation are fineness of ores, reducibility of ores, size and strength of coke, ash and sulphur content of coke, combustibility of coke, size and purity of limestone, and last but not least the maintenance of uniformity of all materials.

In the operation at Carrie Furnaces the raw materials used have the following inferior qualities: the ore is extremely fine; the coke is small in size and not strong, and is also high in ash and sulphur content; and the limestone is irregular in size. The favorable qualities of these materials are reducibility, chemical and physical uniformity of ore; uniform chemical quality of coke; and usually uniform analysis of limestone. Combustibility of the coke has not been mentioned; however, this is a highly important factor in furnace operation and will be discussed more in detail under the heading of Coke Rate.

As indicated previously, the factors effecting production are numerous and it is admittedly impossible to determine by theory the maximum production obtainable. Therefore, the only manner of determining whether a furnace is up to maximum production is a comparison with other similar size furnaces operating on similar raw materials.

TABLE B—DATA CONCERNING THE PERFORMANCE OF CARRIE FURNACES NOS. 1, 2, 6 AND 7 ON THEIR PRESENT LININGS

	Number of Months Operated	Aver. Daily Prod.	Gross Coke	Coke Screenings	Net Coke	Scrap Used Over Prod.	Flue Dust Prod.	Flue Dust Used	Cu. Ft. Wind per Min.	Blast Temp.	Blast Press.
No. 1 Furnace Average on Lining....	15	680	1975	124	1851	+60	319	190	49206	1017	20.3
Best Month		734	2020	150	1870	+76	234	186	51626	1178	20.8
No. 2 Furnace Average on Lining....	19	644	2098	120	1978	+36	380	112	47712	977	19.7
Best Month		703	1974	103	1871	+62	404	233	49690	890	19.8
No. 6 Furnace Average on Lining....	5	689	2126	114	2012	+ 1	334	111	48297	1037	21.3
Best Month		727	1980	132	1848	+46	340	175	50742	954	22.3
No. 7 Furnace Average on Lining....	7	715	2086	124	1962	+28	374	116	50066	1052	20.5
Best Month		752	2068	150	1918	+51	386	60	51251	1049	21.1

Table B gives the average records of Carrie's large hearth furnaces over the entire period of their operation, and in addition gives the individual records of their highest average production for a period of one month. These productions are comparable with equal size furnaces operating on soft ores and using coke made from 100 per cent high volatile coals. They are, however, somewhat less than that of furnaces using the same ores but using coke made from a mixture of high and low volatile coals. This indicates that such coke is superior to Clairton coke in quality. This conclusion is further strengthened by the experience of the Jones & Laughlin and the Weirton Plants, that have operated on both types of coke. Both plants have proven to their own satisfaction that the production can be increased about 10 per cent by changing to coke made from mixed coals. They give as the reason, their ability to blow higher winds with no increased production of flue dust; and no increase, but rather a decrease in coke rate, and their ability to carry higher blast temperatures. This indicates that the stock column has been made more permeable to the blast, and that the coke, either due to higher blast temperatures or increased combustibility, burns more readily with a lower zone of fusion, permitting higher winds with no increase in the coke rate.

Coke Rate

The net coke rate at the Carrie furnaces compares favorably with any present operation regardless of types of raw materials used. This is unusual as, compared on the basis of the generally accepted standards affecting coke practice, they have many unfavorable operating conditions affecting the coke rate. Their gross coke rate is high because of the large amount of screenings that are removed at the furnace. This is the characteristic practice of all plants using Clairton coke, as it has been definitely established that with this coke the improved furnace operation resulting from intensive screening more than compensates for the amount of coke lost thereby as furnace fuel. The cost of Clairton coke is low, and a comparatively slight improvement in furnace practice compensates for the loss of the coke screened out. At plants where coke prices are high, the economic relation may change to an extent that forces the use of fines with the rest of the coke in order to prevent the wasting of high priced fuel. This condition I believe is largely responsible for the divergence of opinion existing among operators upon the value of screening the coke at the furnace.

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*Paper read before the American Iron and Steel Institute, New York, May 20, 1927.

†Superintendent, Carrie Furnaces, Carnegie Steel Company, Rankin, Pa.

Among the adverse factors affecting Carrie's coke rate is the low fixed carbon content, which averages 86.88 per cent. Since carbon is the only content of coke useful to the furnace operation, the value of a coke is directly proportional to its fixed carbon content. Other adverse factors are the high sulphur content which necessitates a high basicity of slag to insure good quality of iron; a higher ash content, causing higher slag volumes; and finally the necessity of a low blast temperature on account of the furnace reaction. A high ash content can be compensated for by the use of lower silica ores, but the inability to use high blast temperatures must be reflected in higher coke consumption. However, in spite of these generally recognized deficiencies, the coke rate at Carrie is very good. In analyzing this unusual condition one is forced to the conclusion that the speed of combustion of Clairton coke is better than that of other coke seemingly more free from the handicaps observed, and that the advantages gained by this one feature are sufficient to compensate in a large part for all of the detrimental characteristics mentioned.

The rate at which coke is burned to CO_2 by the oxygen of the blast and this CO_2 later converted to CO by the incandescent coke farther from the tuyeres, has been generally considered a variable, dependent mainly upon the character of the coke, and this rate has been termed the combustibility of the coke.

Due to difficulty in maintaining test conditions similar to that existing in the furnace, experiments to determine this combustibility have not reached the stage where conclusions are dependable. A series of such experiments was made at Carrie Furnaces in 1922. They included only Clairton coke, and therefore brought out no comparative values in the combustibility of various cokes. They did, however, indicate very definitely that the combustibility of a given coke is directly dependent upon size, and as this feature of the test agrees with my conclusion and was in fact to a great extent responsible for such conclusion, it is herewith shown.

The test was made by burning the coke in a brick-lined furnace 14 in. in diameter and 46 in. high; the air was supplied through the bottom of the furnace at a constant rate in the following manner: The air pressure was kept constant at 120 oz. on one side of a diaphragm containing a 5/16 in. hole. As the pressure on the furnace side was only 20 oz., and varied but little from this pressure, the total pressure drop through the orifice stayed within 1 per cent or 2 per cent of the average in all cases, thus guaranteeing a constant supply of air.

Previous to making the burning test a preheating charge consisting of 10 lb. of small wood and 50 lb. of coke was put in the furnace. This was burned at test conditions for two hours. The furnace was then cleaned out, and immediately filled with 10 lb. of small wood and filled to the top with test coke. The blast was then turned on, and the test continued for two and one-half hours, during which period all of the 100-lb. sample was charged. At the end of this time the residue was cleaned out of the furnace and weighed. The amount of residue was subtracted from the original 100 lb., giving the amount of coke burned. Gas analysis was taken at intervals from the top of the furnace and the averages of these are given in the results.

The test showed conclusively the marked increase in combustibility effected in the same coke by reducing the size. The results obtained are further substantiated by the gas analysis which shows for the slower burning coke a lower CO content and a higher CO_2 content than obtains with the faster burning coke.

This test brought out also the necessity of maintaining a definite relation between height of test furnace and quantity of wind blown, because if the test furnace were sufficiently high so that the reaction $CO_2 + C = 2CO$ were completed in all cases, then with the same quantity of oxygen supplied there would have been equal amounts of carbon burned and the test would be valueless.

Referring back to the comparison of Clairton coke with the other coke, it was stated that Clairton coke is smaller and also contains more cross fractures, which cause it to break up still more in its passage through the furnace. The result is that the size of this coke in the furnace bosh is very small, and by virtue of its small size the combustibility is increased. This, I believe, accounts for the ability of operators using Clairton coke to compare favorably in coke rate with others using higher blast temperatures. The greater surface exposed by the smaller coke per unit of weight is no doubt entirely responsible for the increased rate of combustion in accordance with the well-known fact that the speed of combustion of a given substance is dependent upon the surface exposed. The gain in combustibility by this method is, however, not to be recommended, since the evils in the use of small coke are many, and in most cases will suffice to overbalance the advantages gained. The theory, however, is interesting, and it is possible that

TABLE C—TEST OF SPEED OF COMBUSTION OF COKE RELATIVE TO THE EFFECT OF COKE SIZE

Kind of Coke	Amount Pounds	Coke Pounds	Pounds	Gas Analysis		
				CO	CO_2	O_2
Clairton, natural size	100	47.0	53.0	12.4	9.6	0.8
Clairton, natural size	100	43.5	56.5	18.8	7.2	0.8
Clairton, crushed to through 1½ in. screen	100	57.0	43.0	20.8	4.0	0.0
Clairton, crushed to through 1½ in. screen	100	59.5	40.5	23.8	2.4	0.1
Clairton, crushed to through 1 in. screen	100	65.5	34.5	22.0	1.6	0.2
Clairton domestic coke*	100	63.5	36.5	22.8	5.6	0.0
Clairton domestic coke*	100	63.0	37.0	27.6	2.0	0.0

*Domestic coke averages about 1¼ in. in size. All samples were thoroughly screened over ½ in. screen.

in certain operations where blast pressures are low, the movement of the furnace is smooth, and fluid acid slags can be carried, crushing the coke to a size consistent with the maintenance of smooth regular operation possibly would result in a betterment of coke practice with a consequent increase in production. Operators using hard ores especially, since they are not dependent upon the coke alone to maintain permeability of the stock column, would seem to have an excellent opportunity to try out this possibility.

It would seem then that the coke should have two definite physical qualities: First, it should be sufficiently large, dependent upon the fineness of the rest of the burden, to establish permeability of the stock column that will result in a smooth driving furnace with low flue dust production; second, it should be sufficiently small upon entering the bosh to effect a rate of combustion at the tuyeres consistent with good fuel economy. As these two desirable qualities are diametrically opposed, it follows that neither can be fully realized, and a compromise must be made, dependent upon the operation considered.

One other factor favorable to lower coke rate in operation with Clairton coke is the high blast pressure experienced, which is 2 lb. or 3 lb. greater than obtains in most operations, the greater pressures having the effect of accelerating the reaction in the furnace bosh.

Before leaving the subject of coke rate and combustibility of coke, mention should be made of tests made at a number of furnaces by the Bureau of Mines, under actual operating conditions, of the speed of combustion of coke. These were made by traversing the section in front of the tuyeres with water-cooled tubes through which gas samples were drawn. The conclusion of the investigators as a result of these tests was that complete combustion of the coke to CO is accomplished at a fixed distance from the tuyere nose (about 40 in.) in all cases, regardless of coke size, coke quality, blast temperature or velocity of wind through the tuyere. Such conclusions are directly opposed to the theories held generally by furnace operators based upon their observations of actual operating conditions. While full consideration must be given to the Bureau of Mines for the extreme thoroughness of its work and the high class of its investigators, operators in general are not prepared to accept results so directly opposite to theories that agree in every respect with their actual experiences.

Blast Temperature

The beneficial effects gained by heating the blast became known in the early days of furnace operation, and with the exception of the period of transition from hard to soft ores, the limits of blast temperature have increased steadily throughout their development, until at the present time heats as high as 1,300 deg. F. to 1,400 deg. F. are used at many plants.

Efforts to avail Carrie furnaces of the advantages of the extremely high blast temperatures used in modern practice have not so far been successful. The large hearth furnaces have shown a marked inability to use much more than 1,000 deg. F. to 1,100 deg. F. temperature. Any attempts to raise the temperature above these limits result in increased blast pressure, the furnace becomes irregular, and checking and rolling occurs.

The necessity in this particular operation of maintaining regular movement of the furnace, so as to prevent excessive production of flue dust and the consequent derangement of the furnace, has been emphasized previously in this paper. Therefore, the best results in operation are found where the blast temperature is held within the limits consistent with regular driving of the furnace. In analyzing this, two conditions are found that seem mainly responsible for the trouble existing. Both of them are dependent upon the generally accepted principle that a limey furnace will not take the heat.

The first of these conditions is the fact that in order to keep within the desired sulphur specification of 040. per cent and under in the iron it is necessary, due to the relatively high sulphur content of the coke (1.01 per cent average) to run fairly limey final slags. The ratio of bases to silica in the slags averages about 1.4 to 1, whereas on furnaces using coke of low sulphur content ratios of 1.15 and 1.20 to 1 are usual.

The second condition is due to the relatively higher silica content of Clairton coke, averaging 5.61 per cent. Taking an average burden, 25 per cent of all the silica in the charge is contained in the coke. This silica is not released to the slag until the coke has been burned at the tuyeres. It follows that the lime content of the slag formed above the tuyeres is greater than that of the final slag in proportion to the percentage of the total silica of the burden contained in the coke.

As both conditions tend toward a more limey slag above the tuyeres than is found in most operations, the combination produces an excessively limey condition in this practice which is probably largely responsible for the inability to use high blast temperatures.

Flue Dust Produced and Consumed

Carrie's flue dust production is high, the amount produced ranging around 400 lb. per ton. Flue dust has been used in varying amounts throughout the campaign of these furnaces. They are now using about 50 per cent of the dust produced, and it is found that attempts to use higher quantities have resulted in more than proportional increases in flue dust produced. There seems to be a cumulative action in dust production which indicates in this operation that 400 lb. per ton is about the maximum dust production permissible. If the production exceeds this figure for a continued period inferior furnace operation results.

The flue dust problem in general has become increasingly serious with the present use of higher winds. While plants operating on coke from mixed coals are able to use a larger percentage of raw dust, I do not know of any operation blowing the present high winds that is able to consume all of their raw flue dust, as such.

The inability to use large amounts of raw dust at Carrie is evidently due to the small initial size of the coke, and also to it stendency to break up further during its passage through the furnace. This has the effect of reducing the voids in the stock column, thus increasing the velocity of the gases and their ability to carry more dust out of the furnace. This condition has reached such a stage under the present operation with high winds that it is sometimes difficult to bring sufficient burden down to the hearth to hold the silicon down, and it has actually been possible under certain conditions to bring more burden down by taking off weight. The reason for such an unusual occurrence is that the more open burden, resulting from reducing the amount of ore in the charge, causes a reduction in flue dust due not only to the increase in voids, but also to the more regular driving of the furnace. The resultant reduction of flue dust produced more than offsets the amount of burden taken off the furnace.

Considerable experiments and investigations are under way to find some means of reducing the present excessive flue dust production. Watering of the ores in the skip before hoisting to the top of the furnace effects a very appreciable reduction, and is being done at most plants.

Attempts are also being made to change the distribution of the stock so that the exit of the gases from the top of the stack will be distributed more evenly over the top of the stock, which will result in lower gas velocities, and with consequently less dust produced. The present filling, using a large bell about 4 ft. less in diameter than the stock line, produces a conical contour of the stock in the top of the furnace, with the greater proportion of the fines against the wall and a corresponding greater proportion of coarse materials in the center of the furnace. Recent experiments at furnaces using this type of filling have shown an unusually high gas velocity in the center area of coarse material, and very low velocities in the annular ring between the central area and the furnace walls. The high velocity of the gas leaving the central section is believed to be responsible for the greater part of the dust production. As a means to eliminate this condition one plant is installing a McDonald distributor to throw more of the fines of the burden into the central area and thus produce a stock column of approximately the same permeability throughout its cross section. By this means all of the stock line area will be utilized for the exit of the gas at much reduced velocities. The possible effects of such a filling, not only on flue dust produced, but on the operation of the furnace as well, are very interesting, and may result in developments of much value to the operator.

Movement of the Furnace

The downward movement of the burden materials is retarded by the lifting action of the blast, the friction of the furnace walls, and the upward support of the converging bosh walls. Of these factors the effect of the lifting action of the blast is the most readily calculated. Mr. J. E. Johnson in his book upon "The Principles, Operation and Products of the Blast Furnace" made a very thorough calculation of the retarding effect of the blast pressure, and showed that a 14-lb. pressure difference between the bottom and top of the furnace offers a resistance equal to 50 per cent of the total weight of the charge in the furnace. This retarding effect of course increases as the blast pressure increases, and becomes a serious factor in operations using Clairton coke where the regular driving pressure of the furnace is about 19 lb. or 20 lb., fully 2 lb. or 3 lb. more than with furnaces of equal size and wind volume using other cokes. These high blast pressures are due to the small sized coke, which as stated before has the effect of making a more compact stock column with less voids, offering greater resistance to the passage of the gases. The retarding effect of the blast upon the downward movement of the stock is therefore considerable, and as a result it is difficult to keep such furnaces moving regularly. This tendency appeared early in the operation of Carrie's first large hearth furnace, and was the cause of considerable investigation. The factors mentioned as retarding the downward movement of the stock include the friction of the stock on the furnace walls. As this friction is generally considered to be dependent upon the batter of the inwall section of the furnace, the feature was made the subject of study. The inwall batter of the first large furnace had been made equal to that of the smaller furnaces, which had proven sufficient. Further analysis of the subject brought out the very interesting and logical conclusion that the batter of the inwall is not a proper measure of the expansion rate provided for the descending stock. In considering a section of stock as it is being heated in its passage through the furnace, it is evident that it becomes larger in volume, and therefore involves three dimensions. However, as it is free to expand in a vertical direction, one dimension is eliminated, and the expansion factor becomes one of area. Therefore, in order to maintain uniform expansion rates in different sizes of furnaces, as would be expected if they are using identical raw materials, it is necessary that the relation of the stock line area to the bosh area remain constant. This involves an increase in the inwall batter as the furnaces become larger. The effect may be seen in the following example. A given furnace has a 15 ft. 10 in. stock line, 22 ft. bosh, and an inwall height of 45 ft. The inwall batter is therefore .93 in. per foot, and the ratio of area of bosh to stock line 2.15 to 1, which may be termed the measure of its expansion rate. It is desired to build a large furnace of 25 ft. bosh and retain the same expansion rate. Using the factor 2.15 to 1, it is found that this furnace will require a 17 ft. stock line. Assuming the same distance between stock line and bosh as before, the inwall batter will be 1.07 ft. as against .93 in. on the smaller furnace, or an increase of 15 per cent. Had the inwall batter been kept constant, then with a 25 ft. bosh we would have required an 18 ft. stock line, and the ratio of bosh area to stock line area would have dropped to 1.93 to 1, as against the original ratio of 2.15 to 1. This represents a reduction in expansion rate of over 10 per cent and would no doubt cause increased resistance to the stock movement, and result in higher blast pressures and more irregular working of the furnace. Fig. 4 gives an illustration of an original furnace and its expansion to a larger size, maintaining the same expansion rate in the other.

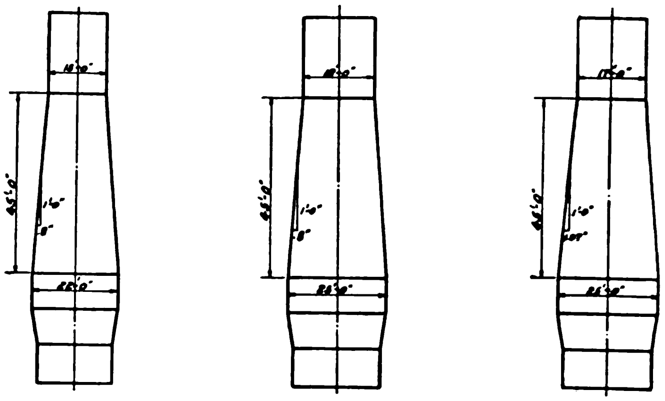

FIG. 4—Comparison of rate of expansion to inwall batter.

(Continued on page 343)

Making Basic Open-Hearth Steel

The Author, Who Is a Practical Steel Man, Discusses Several Features Such as Furnace Construction, Operation, Charging and Heat Control

By C. W. VEACH*

THE prime requisite for making basic open-hearth steel is a sharp working furnace, and a sharp working furnace presupposes several other conditions, namely, properly proportioned flues and checker chambers, adequate draft, control of the flame as to volume and direction, and adequate mechanical devices for reversing the flow of gases, and admitting the proper amount of air to the combustion chamber. And we can say truly that we have a sharp working furnace when at the end of a campaign of 550 heats the furnace works as speedily and uses no more fuel than it did when the campaign was first started six or eight months before.

The tendency of many open-hearth furnaces to become loafers after some 200 heats have been made, is well known, and the reason they slow down is because the checkers become clogged and the flow of the products of combustion away from the combustion chamber is retarded, and in many cases the flame rolls across the furnace like a fog, causing a smoky, dull flame which formerly was white and sharp. And where this condition prevails it is evident that production costs are greater than they would be if the furnace continued to work sharply until the end of the campaign. And the furnace campaign will terminate only when the entire furnace is worn out if the checkers remain open as they should instead of clogging and making it difficult to melt heats and bring the metal up to the desired temperature for tapping.

Searching the literature we find much that is enlightening on the subject, but more in regard to calculating thermal efficiency perhaps than that which is helpful to us in the construction of our furnaces, and more particularly in regard to methods of laying the checker brick as well as the cross sectional areas and depth of the checkers. Practice does not prove that a minimum of about 13 ft. depth is required in checkers in order to arrest and store a sufficient quantity of heat as recommended by one authority. The most efficient set of checkers I know of has a depth much less than 13 ft., but has a correspondingly greater cross sectional area, and the criterion by which I judge of their efficiency is the number of heats made over them, and the time it took to make the last heat of the campaign. The number of heats in question was 659, and the time it required to charge, melt, refine and tap the last heat of this campaign was something less than five hours, and while the heats were only 20 tons the use of the comparison is none the less valuable because the average time was five hours per heat throughout the campaign.

The same furnaces are at the present time making 31-ton heats in an average of 6 hours 20 minutes from charge to tap, and this time is not materially increased after 450 heats have been made and the furnace has become well worn in most of its parts causing considerable more air infiltration than when the furnace was new, and much more heat lost by radiation through the roof and side walls.

Putting Furnace on Production

Continuing this discussion take into account the various steps required to put a new furnace on production. First, bring the brickwork up to a tempearture that will enable burning in the bottom layer by layer. This temperature will be about 3,000 deg. F. and must not become much higher lest the unglazed bricks be damaged, nor should it be allowed to fluctuate while the materials, magnesite and slag, is being added and burned in or a poorly sintered bottom will result.

The object aimed at when starting a new bottom should be to close all the interstices between the bricks which were not closed by the expansion of the bricks while heating up.

This will be accomplished by adding basic slag and melting it in so that it fills all cracks, and when this is accomplished a thin layer of magnesite mixed with slag, about 75 per cent magnesite to 25 per cent slag, and repeating this operation as rapidly as the magnesite addition becomes properly sintered.

After a union between the magnesia bricks and the first few rounds of magnesite and slag is assured succeeding rounds of magnesite with just enough slag to insure its sintering properly will be added at stated intervals of time, but in order to carry out a definite program of adding the rounds of magnesite the furnace must be kept at a uniform temperature.

About the third day the bottom will begin to take form when on about the sixth day the tap hole will be put in and the banks brought up to the desired height and thickness.

When complete the bottom will represent a shallow dish, and should slope from the ends to the tap hole which is placed in the exact center on the back side, and at the very lowest point to insure easy drainage of the bottom when heats are tapped.

An experienced operator may easily judge when his bottom is full enough, that is when the thickness of the bottom and banks is what they should be, but the best criterion by which to judge when the bottom is nearing its completion is to calculate from the amount of material that has been added, providing of course the material has been uniformly distributed.

Usually one or two courses of chrome bricks will divide the magnesite bricks of the hearth from the silica bricks constituting the walls, and when the bottom is complete the banks will cover the chrome bricks, and during the first few days after the furnace has been put in operation a protective coating of chrome ore will be built up from the banks and extend well up towards the skew back.

This method of protecting the walls of the furnace, and incidentally the bottom, extends the life of the walls directly, and extends the life of the whole furnace indirectly by preventing several week end repairs which would require that the furnace be cooled down which every one must realize is detrimental to the structure of the whole furnace, especially after the material has worn thin.

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*Bettendorf, Ia.

The walls being covered with chrome ore, which is neutral to silica, will carry the silica, which comes down from above, over the magnesite banks of the bottom and deposit it into the bath where it can do no harm.

If the banks of chrome ore are neglected the fused silica will work its way down between the wall and the bank and cut through the bottom at or under the slagline, and if not causing a breakout ultimately at least it will weaken the bottom and cause a delay while it is being repaired.

Furnace Charge

First we have to consider the selection of the materials that go to make up our charges, in brief a balanced charge in regard to the carbon content and manganese content of the material, and its physical condition and what effect this will have on the carbon and manganese when the heat is melted and ready to work preparatory to tapping.

It may be objected that to segregate the different classes of scrap and pig iron according to their chemical analysis and physical condition, involves an unnecessary expense, but in the long run there is no extra expense because the better control segregation affords cuts costs in some other way that more than offsets the space required for storage above that required for promiscous storage.

Of course where hot metal is used the pig is uniformly mixed and only the scrap need be segregated and used according to formula.

There are something like 50 classifications of scrap iron and steel if not more, and if we buy a dozen different grades and then pile the whole in a common heap we cannot even approximate the carbon content, nor can we judge how much of one particular kind enters any one heat, or whether too much or too little of the rusty scrap is being weighed up.

Furnace Control

The factors of control are more especially required in plants using the smaller sized furnaces, and particularly those using a cold charge, however, it is quite possible that some of them if not all are being followed in large plants using the larger melting units and using hot metal. For, whatever the size of the furnace or the nature of the charge there is more or less of indeterminateness with which iron oxide is introduced, either carried into the bath as rust or scale or is formed as Fe_3O_4 during the time of charging and melting down.

If the open-hearth furnace was similar in all respects to an automatic machine, that is, if it could be depended upon to perform as regularly and consistently as a machine we would find it less difficult to judge of its performances ahead of time than we do, but there are always contingencies which have until very recently challenged our ability to eliminate, and we have been wont to say with "good luck" our furnace will produce thus and so, hazarding interruptions over which it was supposed no control could be exercised.

And for all those producing steel in furnaces up to 30 tons capacity the causes alluded to will assuredly affect the quality of the product, and will affect the cost whether the unit is large or small, much depends, therefore, on the intelligence of the operator, but however intelligent the operators may be they sometimes do a certain thing in a certain way because it worked out when done that way cn previous heats.

Character of flame

Glancing into a furnace we see that the metal is almost all melted, yet there is still a turbulence here and there indicating that the lime is not all up, and we know that the lime sticking on the bottom is not yet calcined, that is, it still contains CO_8 which is coming off and which causes the disturbance. We may also note that the operator had "cut" his flame back to a point where it barely keeps the action going, while the operator is biding his time till the remainder of the lime comes up when he will proceed to work the heat, and if we question him as to why he is running so short a flame he will give one of two reasons.

First, he may point to a thin watery slag, in which event we know our own suggestions are being carried out, i. e., that when the slag thins out before the phosphorous has been taken care of care must be taken not to allow the metal to become hot for then it will be difficult for us to eliminate phosphorous, in other words, if our heat melts open, that is, if our slag is thin and watery just previous and subsequent to melting and we have an excess of carbon the metal will become very hot in a few minutes, and high temperature militates against the removal of phosphorous, and the open-watery condition of the slag presupposes the presence of excess acids, and more than likely too much silica has been introduced with the charge, either as contained silicon or as sand (silica) adhering to the steel scrap or contained in the limestone or both.

While the bath is still at a low temperature make sure that the phosphorous is within limits by adding dolomite or lime, and at the same time prevent undue cutting of the bottom at the slag line.

The second reason the operator will give for running a short flame on his furnace chances are will be as follows:

"By the action I figure the carbon is going to be way high, and by running a short flame it wont melt so high."

Very true, but how many operators understand what it is that causes the carbon to be less in amount when a short flame is maintained during the last hour or two that the charge is melting?

We may be sure that the number is very small, for this question involves one of the prime factors of making steel by the basic open-hearth process, and that it influences the cost of production when practiced there can be no doubt as we shall see.

The fact of the matter is that when the operator cuts the volume of the flame to prevent the heat from melting with too great an excess of carbon he simply decreases the ratio of combustible to oxygen entering the combustion chamber, and increases the oxidizing influence of the furnace atmosphere inversely as he reduces the flame.

Now supposing he has maintained as sharp a flame up to this time as he could develop, and that while the melting process has been going on the furnace brickwork and the banks have been raised to a temperature a little higher than the melting mass, this sensible heat has a tremendous value and will be required during the time that the metal is being brought up to tapping temperature.

And if he reduces the volume of the flame to a point where the furnace atmosphere is sufficiently oxidizing to allow oxygen to have access to the mass of metal (only a relatively small amount of metal being exposed at this stage) in sufficient amount to accomplish his purpose it is apparent at once that such a flame is not sufficient to maintain the brickwork at the temperature it had when the flame was reduced, so this stored energy is simply wafted up the stack and wasted.

Moreover, there is no criterion by which he can judge of the amount of iron oxide that has thus been formed, and its subsequent effect in the removal of carbon, so this method of introducing iron oxide is a much less determinate one than adding ore after the metal is all melted.

As we said before the prime factors of our process are involved in this discussion, and chief of all factors is this: that we utilize fuel, coal, coke, gas or crude oil in large quantities to melt and refine an agglomeration of pig metal, scrap steel, and limestone in our furnaces to make the product most suitable for the use for which it is intended, and the more nearly we are 100 per cent efficient in the control of flame—getting the utmost heat energy tranferred from the flame to the metal—the more nearly will all contingent factors operate as they should and stay within bounds.

The operator may be justified in doing the thing that will make his labor easier, but if the charge is standardized, and as far as possible all indeterminate factors eliminated the procedure of the operator can be standardized and he will be more proficient, not only in regard to the control of his furnace at any stage of the heat, but he will be able to predict what the condition of his heat will be one, two, or more hours ahead of time, and can accordingly govern his steps so that the maximum of result can be obtained at the minimum of expenditure.

Scheduling of Heats

Until very recently no one would have thought that it was possible to schedule the heats a furnace was to make a week or two weeks ahead of time, and if such a schedule had been made—designating the time the first heat of the week was to be charged and tapped and definitely scheduling the time each succeeding heat was to be charged and tapped throughout the week, and definitely stating the hour the last heat would be tapped at the end of the week, very few of us would have believed that such a schedule could be met.

And the reason we would have questioned the value of such a schedule is because of our lack of control, or only partial control of some of the things that may delay the heat by prolonging the melting period, or delay the time of charging, or prolong the working period unduly and upsetting our schedule.

But where the operating factors, from the least to the greatest, have been brought under control such a schedule is not only feasible, but has been in fact put in operation, and it is not difficult to visualize the value of such control, and without going into detail we can predicate some of the advantages it gives.

It presupposes control of the flame to suit the condition the metal is in at any particular stage thereby conserving fuel, it presupposes the fact that the furnace lining is not intermittently subjected to abuse, it presupposes alertness and interest by the operators in their duties, and it presupposes the fact that only a predetermined amount of oxidation takes place during the melting operation.

Lest the very critical find fault with the last statement in the preceding paragraph we must qualify it by saying that there is always a certain indeterminateness with Fe_3O_4 forms during the time the charge is being introduced and melted down, and yet the amount of rust introduced can be governed, and the formation of iron oxide while charging can be controlled somewhat and, other conditions being normal, every heat can be melted so near to the amount of carbon desired to work it down properly that only a little more or a little less ore need be added.

And herein is where the deviation from the scheduled time comes in, yet some heat will require less time to work and others will take a little more time, so that the intervals will equalize themselves, and many heats will be tapped on spot time while none will be off more than about 45 minutes.

One contingency on which the time element depends is the behavior of the bottom, because a sloppy bottom may not only delay the time of charging, but may extend the time of working the heat, for if it comes up time must be taken to splash the steel and slag out of the hole and fill it up again with new material and sinter it in so that it will stay put.

However, several plants have overcome this tendency by giving the bottoms a good washing out and renewing their surface with new material each week-end, and such a practice has a very great influence on the quality of the steel, and it is economy to spend some time on the bottom at the end of each week.

New Steel Plant of the Timken Company

(Continued from page 318)

Blooming Mill and Stripper

The apparatus in the mill building consists of the 125-ton stripper crane, the 5-ton soaking pits crane, the 35-in. blooming mill, and 10 x 10 in. hot shears, and a 20-ton crane for handling the billets in and out of the annealing pits. The principal feature of interest in this installation is the fact that many of the bearing installations represent the first ones ever made to their particular classes of service. For instance, on the stripper crane, the tongs turning shaft and stem thrust bearing is of the tapered roller variety, as are those on the tongs turning lower sheave shaft, operating shaft, and operating sector. The trolley wheels, main hoist, drum shaft, reduction shafts, sheave, and motor back shaft extension are similarly equipped.

The blooming mill is a three-high, 35-in. mill with top and bottom screw down driven by a 1,500-hp. induction motor. All the rolls of the mill approach table, and those of both lifting tables are equipped with Timken Bearings. The side shafts of both the mill approach and lifting tables are similarly equipped. The same is true in the case of the shear approach and depressing table rollers, and the shear approach and depressing table side shafts.

Theory and Practice in "Ragging" Rolls*

Efficiency of Rolls Increased by "Ragging"—Best Form of "Ragging"—Relation of Speed of Rolls, the Ingot and the Lapping of the "Ragging"—Explanation of Lapping

By HANS CRAMER†

THE theoretical efficiency of a roll train, in relation to the finishing pass, is calculated on the assumption, that the finishing pass delivers the product unbroken, and that there is also no time lost between the exit of one bar and the entrance of another. Similarly the theoretical efficiency of a housing, on which several passes are made, is obtained on the basis of the total time of rolling.‡ This rating is, of course, greater than the so called "without loss" performance attainable at best in practice, since there is always a definite period between the exit of the piece from one pass and its reintroduction into the following. We must now try to make the difference between the theoretical and "without loss" efficiency as small as possible. The proficiency of the roller and the smoothness of the grip of the piece by the rolls are dependent upon the excellence of the mechanical equipment. As a result, the difference between the theoretical and the "without loss" efficiency becomes smaller and the production, greater.

It is usually the aim to roll heavy ingots as far as possible, since the time for the incidental work between the exit of the bar from a pass and its reintroduction into the following, is generally independent of the weights of the metal. The thickness of the ingot is limited, among other things, by the gripping capacity of the rolls. Therefore no greater draft can be used than the angle of grip allows. It is better to stick to a small ingot if it is not grasped securely and smoothly by the rolls. The "without loss" efficiency will be less in spite of the greater weight of the ingot, due to the intervals between the separate passes resulting from the poor grasping by the rolls, than in rolling on ingot of small cross section, but which is gripped securely and smoothly. When an ingot comes in contact with two rolls they will pull it through if the friction between the ingot and the piece is equal to or greater than the resistant force R, which is dependent on the force of compression K and the angle of grip α. Fig. 1 shows $R = K \sin \alpha$. The component due to friction M, is the product of the angle of friction tan p and the force W acting perpendicularly to it, which passes through the center of the rolls and which is produced by the force of compression K ($W = K. \cos \alpha$), i. e., $M = K. \cos \alpha \tan p$. In extreme cases in which the rolls still grip, the component due to friction M is equal to the resultant force R. Therefore:

$$K. \sin \alpha = K. \cos \alpha \tan p$$

$$\tan p = \frac{\sin \alpha}{\cos \alpha} = \tan \alpha$$

The rolls still grip if the angle of grip α is equal to or smaller than the angle of friction p. With equal roll diameters the angle of grip is a function of the draft:

$$\cos \alpha = \frac{AB}{AC};\ AC = R;\ AB = R - \tfrac{1}{2}(h_1 - h_2)$$

$$\cos \alpha = \frac{R - \tfrac{1}{2}(h_1 - h_2)}{R} = 1 - \frac{h_1 - h_2}{2R}.$$

If a greater efficiency is desired, with the same number of passes by raising the roll draft, through which the angle of grip is enlarged for the same roll diameter, then the angle of friction must be increased. This is dependent upon the roughness of the rolls and of the piece. For large roll draft the rolls are artificially roughened, that is they are ragged, since the roughness of the piece cannot be altered. Various experiments undertaken to determine the angle of grip with which the rolls bite evenly, have yielded values which lie between 22½ deg. and 24 deg for smooth rolls and between 30 deg. and 34 deg. for roughened rolls. Only small differences in the angles of grip can occur in the case of smooth rolls, but these are increased with ragged rolls where the difference of 4 deg. is more than twice as large as for smooth rolls. This is evidently due to different degrees of ragging.

Types of Roll Ragging

Various types of roll ragging are shown in Fig. 2 as they are employed in practice. The forms are differentiated according to: (a) parallel worm grooves, (b) plain bevel and (c) inter-crossed bevel worm grooves, (g) single angular, (e) multiple angular, and (f) many grooves and (d) ragging by center marking or (h) by dotting. The grooves are produced either with the same depth in all places, or reduced gradually towards the ends. The latter are used principally for arched passes (Fig. 3). Various forms of cross-section are also used of which several are reproduced in Fig. 4.

To insure a secure grip of the metal the shape and the depth of the roll ragging are often made too large. These then are lapped along the edges by the collars of the following pass when they are rolled through a direct draft, and cause considerable waste.

It is usually the aim to make the elongation of the bar as great as possible for the same cross section and some absolute draft by the prevention and elimination of spreading. This is however not always possible with ragged rolls, if the lapping of the indentations is to be prevented. For smooth rolls the least width of a pass before it is edged needs to be equal only to the height plus the sum of the depth of the ragging in the top and bottom rolls of the preceding pass. The pass being too narrow, the indentations are lapped by the grazing of the collars as is shown in Fig. 5a, before the metal receives any draft at all, when the ingot is still at the shaded portion in Fig. 6. The collars have a greater velocity

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*Stahl und Eisen, April 7, 1927.

†Translated by Victor S. Polansky and Morris Schrero, Carnegie Library of Pittsburgh, Pa.

‡W. Tafel. St. u. E. 43 (1923) p. 370.

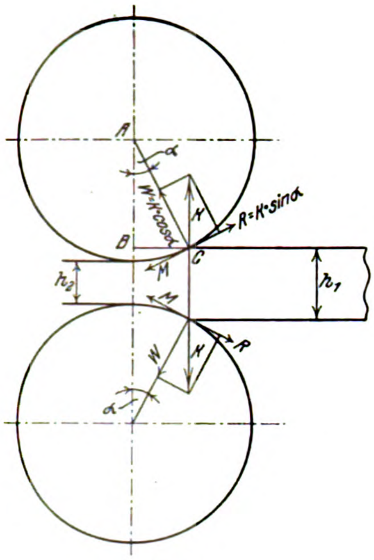

Fig. 1

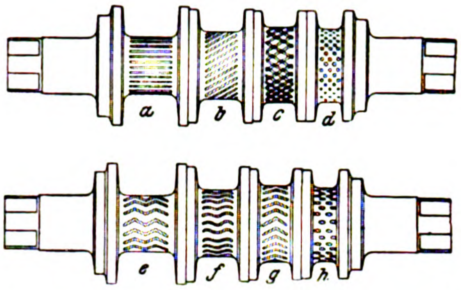

Fig. 2

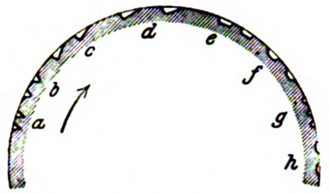

Fig. 4

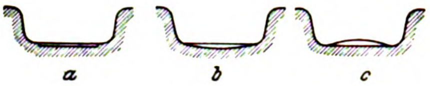

Fig. 3

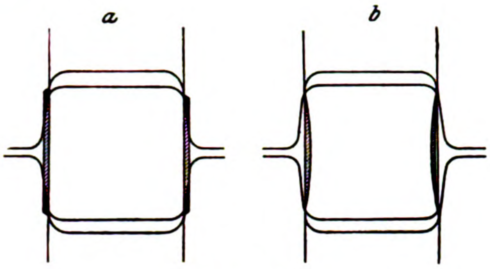

Fig. 5

FIG. 1—Forces arising during the gripping of the ingot. FIG. 2—Various forms of roll ragging. FIG. 3—Longitudinal section of various forms of roll ragging. a—Same depth in all places. b—Gradually run out at the ends. c—Same as b, in arched passes. FIG. 4—Various cross-sections of ragging. a—Sharp pointed ragging. b—Sharp pointed ragging rounded off. c—One-sided sharp pointed ragging. d—One-sided sharp pointed ragging rounded off. e—Flat ragging. f—Flat ragging rounded off. g—Semi-circular ragging. h—Oval ragging. FIG. 5a—Lapping of the ragging by the collars before going through a pass. FIG. 5b—Improvement of the ragging if working without spreading is desired.

in all places than the entering bar, since the speed of entrance of the metal is less than the peripheral velocity of the rolls. Therefore the indentations are lapped along one side in the direction of the passage of the bar through the rolls. In this case a disadvantage not to be underrated results in rolling with ragged passes. In working with smooth rolls, without any spreading, there occurs, in addition to an advantage of greatest elongation, a strong diagonal "running through" of the metal and a very good guidance of the bar. In order to obtain a diagonal "running through," especially with alloy steels, there frequently results however, greater wear of the collar and a greater demand of power, owing to the slipping between the collars and the metal. Besides, the greater roughness of ragged rolls in contrast to smooth rolls does not find complete acceptance, since with smooth rolls the gripping ability of the rolls increases with the force corresponding to the working diameter in considerable amounts, through the assistance of the roll collars, since thereby the working diameter is enlarged to a certain degree. In order not to give up the advantage of ragged rolls, in all those cases in which it is desired to work without spreading, arched passes are chosen (Fig. 3c). Thus stripping of the indentations is avoided even before the ingot has received any draft. (See Fig. 5b, left side). In order to avoid fins, in this manner of working, not only the pass itself is arched, but also the ragging. (Fig. 5b right side). The curvature of the entering ingot must be greater than the curvature in the depth of the pass. In the passage through the rolls the ingot then receives less draft at these places than in the center and does not tend to form seams. As mentioned above the width of the pass must be at least equal to the height of the preceding pass, plus the sum of the ragging in the top and bottom rolls in order to prevent the stripping of the ragging, while the ingot is at the shaded place shown in Fig. 6. The relations in further through the rolls, for the realization of the foregoing condition will be considered.

Velocities in Rolling

First a description of the velocities in rolling will be outlined. The speed with which the bar leaves the roll planes M_1, M_2, (Fig. 6) is called the roll velocity. This speed of exit corresponds neither to the paripheral velocity of the rolls based on the working diameter of the rolls D, nor to that based on the average roll diameter Dm, but is equal to the paripheral velocity of a roll with a radius* $R + h/4$. The curve for the velocity of the roll collars is drawn in Fig. 7a (curve 1′, 4′, 3′, 5′, 2′), and in opposition thereto the constant speed of exit a of the bar. The ordinates represent the separate points of the height of the pass, while the paripheral velocities corresponding to the respective heights of the pass are laid out on the abscissas. The distance 1-1′ and 2-2′ correspond to a diameter dl, that from 3-3′ to a diameter Dm, those from 4-4′ and 5-5′ to a diameter of $D = D + 2 — h/4$. Accordingly the ingot has a greater speed than the roll collars from 1′-4′ and 2′-5′, whereas from 4′-5′ the roll collars have a greater velocity than the ingot. The ragging is held continuously in contact with the roll collars by the spreading of the ingot, so that with unsuitable form of ragging, rubbing on one side and resulting lapping of the indentations can occur. This lapping occurs between 1′ and 4′ or between 2′ and 5′, because of the greater speed of the ingot and between 4′ and 5′ because of the greater velocity of the collar. The rag. a will thus become rolled at its ends in entering and at the middle in leaving in the direction of rolling indicated by the arrow (Fig. 7b).

To be sure the relations are not quite so simple, since not only the roll planes alone, but also the whole volume from the entrance E_1 E_2 up to the exit A_1 A_2 from the rolls (Fig. 6) must be taken into account. The ragging is in contact with the roll collars and can be sheared by the difference in velocities between the roll collars and the bar, since spreading begins in the plane of entrance. While the velocity of the roll collars at entrance and exit is the same, that of the ingot becomes less from the roll plane A_1 A_2 to the plane of entrance, that is, the difference between the velocities of the roll collars and of the ingot becomes larger. In all cases in which ragged rolls are used, that is, in which the angles of grip is more than 22 deg., the velocity of the collars will be greater than that of the bar (dotted line in Fig. 7a) in all places in the plane of entrance and will become less only gradually towards the exit between 1′ and 4′ and between 2′ and 5′. Lapping of the indentations must therefore occur in the direction of rolling during the passage of the ingot from the plane of entrance to the plane of exit between points 4′ and 5′. Between 1′ and 4′ and between 2′ and 5′ lapping takes place first in a direction opposite to and then in the direction of rolling as is actually shown in practice (Fig. 7b). The inclined position of the lapped ragging is thus directly reversed to the flow of the material in the interior of the bar. The latter has been clarified by the well known investigations of Hollenberg.* The whole vertical surface is not pulled along by the acceleration of the sheared ragging, but only the lapped ragging. The vertical surface itself will scarcely be accelerated since it will not be dragged along by the collars, but will warp even in the middle at heavy draft in the direction opposte to that of rolling. Then there appears without overdraft a remaining behind of the surface of the bar in contact with the smaller roll in contrast to the surface in contact with the larger roll.

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*W. Tafel: "Walzen und Walzenkalibrieren," 1923, p. 63.

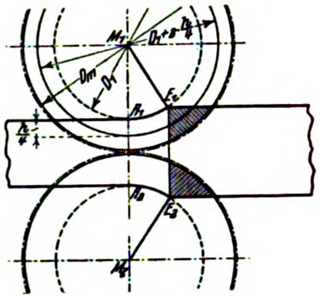

Fig. 6

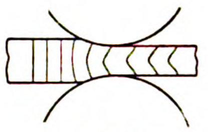

Fig. 8

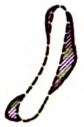

Fig. 9

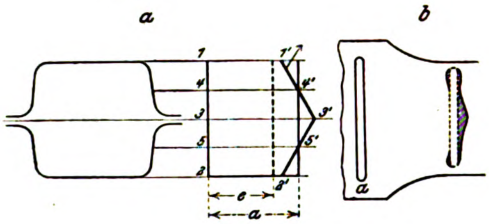

Fig. 7

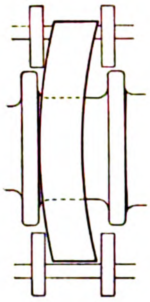

Fig. 10

FIG. 6—Passage through a box pass. FIG. 7a—Velocity of the ingot equals: a—At entrance. a—At exit. Velocity curves of the collars. FIG. 7b—Direction of rolling. Form of the lapped ragging. FIG. 8—Hollenberg's experiments. FIG. 9—Form of the lapped ragging with great overdraft. FIG. 10—Possibility of the lapping of the rags with wide passes.

The accuracy of the "remaining behind" as Metz† has observed in his experiments, can also be determined with lapped ragging. A piece was worked with a heavy overdraft in an open box pass which was cut to more than two-thirds in the top roll and to a third in the bottom roll. The previous vertical ragging showed a lapped form after the pass shown in Fig. 9. It can thus be seen, how the most diverse sheared forms can appear, owing to the various conditions. Now slight lapping of the rags for ordinary brands of iron and steel are not of much importance, since they become rolled and welded by further rolling. On the other hand great stress is laid on the most perfect ragging for rolling alloy steel.

Greatest Safety Lapped Ragging

The ragged form which offers the greatest safety lapped ragging, is that shown in Fig. 4h. If there should occur here a shearing of the ragging then of course the form of the ragging will change, but still no lapping will take place. To be sure, the roughness of the rolls is not too large in this case. To increase this one must depend on the form of the pass shown in Fig. 3c. In all ragging care must be taken, that a ragging in the curvature of pass is avoided under all circumstances. Since the curvature in the preceding pass is greater the ragging does not receive immediately direct draft. During the gradual approach of the curvature of the profile to the curvature of the pass this slides off over the ragging so that lapping must occur.

If the form of the ragging cannot be used, which limits the greatest roughness of the rolls, then the pass can indeed be made so large that a rubbing of the collars and resulting lapping of the ragging cannot occur at all. But even in disregarding the disadvantage cited above no avoidance of any lapping can be attained as can be seen from Fig. 10, without any further explanation. The appearance of lapped ragging has caused some alloy steel works not to rag the rolls, and to attain great elongation by the avoidance of any spreading. This is however incorrect according to rolling technique. Tafel‡ says that "The proportion of bearing friction must be proportionately larger the smaller the reduction, a fact which Kiesselbach also deduced from the investigations of Puppe. It leads to frequently neglected requirements to always use as much draft as the gripping power of the rolls permits."

A great risk in the inaccuracy of the ragging lies in the methods of producing the indentations—chiseling by hand, hollowing and grinding. Nevertheless working can be done appropriately with a security that lapping can be avoided, even though the ragging is too prominent. There has recently been brought on the market an automatic roll ragging machine which, because of the accuracy with which it produces the required form of ragging will permit the selection of the form of ragging that will enable the greatest roughness of the rolls to be attained.

Summary

The increase of the rolling efficiency by artificial roughening, that is, ragging of the rolls, is, unsuitable form of ragging and inaccurate roll turning, accompanied by difficulties which are conspicuous in the lapping of the ragging. This can be traced back to the differences in the velocities between the rolls and the metal and to the action of the roll collars. Such defects can be avoided by suitable improvement and accuracy in the production of ragging.

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*St. u. E. 3 (1883), p. 121.

†u. E. 43 (1923), p. 914-16.

‡Loc. cit.

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Low Temperature Reduction of Iron Ore

Comparison of Present Method of Producing Iron in the Blast Furnace With That Using a Gaseous Fuel as the Reducing Agent. New Process Attracting Attention

By FRANK HODSON*

THE bulk of the pig iron produced in the United States is manufactured in standard blast furnaces using coke as a reducing agent with limestone for a flux and using hematite iron ore as the iron base. The actual reduction is done by the carbon in the coke becoming gasified to carbon monoxide which in turn takes up additional oxygen from the iron ore changing to carbon dioxide and leaving metallic iron. The final equation is $FeO + CO = Fe + CO_2$.

The hematite ore, containing large percentage of impurities, silica, etc., requires a high temperature to gasify the coke and give the heat necessary to effect fluidity of the silica, limestone, fluxes, etc. A considerable excess of carbon in the form of coke must be provided to cover all these conditions of temperature, melting, heat losses. Not all the carbon in the coke is converted to the useful reducing carbon monoxide gas and not all such gas is effective, as it passes but once through the charge. The thermal efficiency of the blast furnace is, therefore, very low. The latent heat of conversion of solid to liquid iron is also considerable. The air of the blast has to be heated and dryed and large quantities of inert nitrogen carry away heat.

Product

The finished material from the blast furnace is a product called pig iron—high in carbon— useless in itself, except for remelting into commercial iron and steel. It is irregular and uncertain in composition—no two heats are exactly the same—and many of the subsequent troubles with finished iron and steel are directly traceable to the vagaries and uncertainties of the base product, pig iron. It is a product of expediency and custom.

It will be seen, therefore, that the manufacture of pig iron from hematite iron ore in a standard coke fuel blast furnace leaves much to be desired. Metallurgists and scientists have been striving for years to perfect simpler and better processes to get this gaseous reducing agent, carbon monoxide, to iron ore and to produced a more stable and reliable remelting product than pig iron.

Reduction by Low Temperature Processes

Magnetite ore has been the base for most of the work done on this low temperature gaseous reduction of ores because magnetite is a much simpler and richer ore than hematite. It is composed chiefly of iron and oxygen, usually 5 per cent to 10 per cent higher in iron than hematite, with little or no silica or impurities. It is not necessary to heat this ore to melting temperature to remove the oxygen from the iron oxides, nor are we troubled with the necessity for fluxing the impurities with highly refractory limestone. At very much lower temperatures than are needed in the standard blast furnace, gaseous reducing agents like carbon monoxide can be passed through the magnetite to be reduced. Usually the reducing agent is in the form of a gas, high in carbon monoxide, which is burnt, giving both heat for initial reaction and the reducing properties.

In a modern, low temperature, reducing furnace the gas itself can be made from cheap fuels—coal oil, water gas, etc.—outside the reducing furnace and after passing through can be recuperated, regenerated if necessary, and used over and over again in the reducing furnace until all its efficiency is gone.

The product of the low temperature gaseous reduction of iron ore is a semi-metallic product known as iron sponge containing from 90 per cent to 95 per cent metallic iron.

In the earlier experiments iron sponge was a rather loosely held together mass with holes or cavities where the oxygen had separated out from the original iron oxide.

Modern iron sponge is either mechanically compressed or mechanically formed into hard, compact metallic pieces, that, while not so dense as pig iron, will stand any kind of handling. The final composition of the iron sponge is, of course, governed by the composition of the ore used, but one important thing about the process is that even with impure ores, impurities such as silicon, gangue, etc., are never brought to a temperature where they combine with the iron, so they can easily be separated out magnetically after the reduction is complete.

Assuming the use of fairly good magnetite, the product is a very pure iron mass, readily handled, very suitable for melting in open hearth or any other type of furnace. The sponge can be treated hot, directly into a finishing furnace or allowed to cool and then remelted.

Sponge iron can save at least 20 per cent of the time now taken in remelting pig iron in the finishing furnaces, its analysis can be accurately controlled and every test conclusively shows steel manufactured from it is much superior to steel made from pig iron and scrap. The reason for this is, the material has never been in contact with impurities, silica, slag, etc., at temperatures sufficiently high to become contaminated. The ancients, with their low temperature, crude methods, made better iron metals than we do today. The reason is the one just given.

Comparison with Blast Furnace

In the standard blast furnace large excess of coke must be present for reasons already given—there is little or no control of the gas generated, large quantities of inert nitrogen—absorbing heat— are blown through with the air blast. The reducing gases pass but once through the furnace, the product is uncertain and unsatisfactory, the necessary high temperature required is wasteful of fuel and refractory costs for linings are very heavy.

It will be realized the low temperature reduction of ores is bound to be more economical than the older standard method of high temperature reduction by blast furnaces.

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*C. E., Philadelphia, Pa.

Another very important economic consideration is the fact that the immense hematite ore fields of the United States are getting leaner in analysis every year and are being depleted at a very rapid rate. Ores that a few years ago averaged 50 per cent to 55 per cent iron, as mined now run 30 per cent to 40 per cent of iron and costly benefication plants are being installed to bring up the iron content. It is estimated that one of the largest of the United States hematite ore bodies will be exhausted in 12 to 15 years and already Bethlehem Steel and others are going into Chile, Cuba, Africa and elsewhere for ores necessary to keep their standard blast furnaces operating successfully. Hardly any of them operate profitably now unless they have assured markets from their own companies' consumption. The solution lies, not in going abroad to keep running a plant already more than half obsolete, but in finding the process to economically use the enormous United States reserves of better and purer magnetite ores.

Recognition of the New Processes

The recent twenty-fifth annual convention of the American Electro-Chemical Society held at Philadelphia, April 28 to 30, 1927, held a special technical session, presided over by Frank Hodson of Philadelphia, on the "Gaseous and Low Temperature Reduction of Ores." Papers were given by scientists and metallurgists from all over the world. It is quite evident the process has come to stay and has the approval of both scientists and practical men. The Steel Corporation is spending $5,000,000 on experimental work on the subject and has its first plant well under construction at Lorain, Ohio.

The soundness of the theoretical considerations for advocating such a radical change in iron ore reduction has long been established and in addition, during the last 10 years, a great deal of practical work has been done. Many and various designs of equipment have been tried for reducing iron ores at low temperature and most of them demonstrate the process is feasible and practical. After that it comes down to selecting the process that has advanced farthest in practical test and this can be measured by the thermal efficiency of the reducing furnace.

Mr. Oliver Smalley, formerly Director of Metallurgical Research for W. G. Armstrong Whitworth & Company, and Mr. Frank Hodson have been working actively on the problem for the last 12 years and have also had the advantage of the work done on the Beardmore-Pherson process at Wm. Beardmore & Company. Almost every type of design has been tested and the definite statement can now be made that a plant can be built to make a high grade metallic reduced iron from magnetite—at a definite cost per ton of product produced. The actual reducing furnace will have a thermal efficiency of 95/97 per cent as against from 30 to 60 per cent in any other type of equipment.

Cost of conversion of a standard grade of magnetite ore into metallic sponge iron is given below.

1.5 tons of ore at $3.00 ton................	$ 4.50
700 lbs. of coal at $6.00 ton................	2.10
250 kw. house power at 1 cent............	2.50
Labor and supervision....................	1.00
Interest and depreciation	.75
	$10.85

Cost of finishing the product into steel, if treated hot in one process, will not exceed $7.00 per ton, or if remelted from cold, $10.00 per ton.

Initial cost of plant with suitable buildings will be approximately $200,000 for 100 tons per day output.

Iron sponge produced in Sweden and not near as good quality, and not metallic, is selling readily here at $43 per ton for 100 ton lots.

The steel produced from this product can be guaranteed to be far superior in quality and test to any steel of the same chemical analysis made in any standard method from pig iron, scrap charge.

The metallic sponge iron produced can be used exactly as pig iron or scrap in any type of melting furnace. It will lessen the melting time in open hearth 25 to 30 per cent.

The advent of a new and proved process of this kind completely changes the economies position of deciding where to install a reduction plant. It is no longer necessary to build near sources of good coking coal as almost any fuel that will gassify can be used and only require 700 lbs. of coal per ton of product instead of something like two tons with older processes. Plant can be installed at the mines and the finishing into steel done near cheap electric power or other fuel supplies. Instead of paying railway rates on large quantities of iron ore, coal, limestone, scrap, etc., one will have the railway rate on minimum quantity of fuel and on a finished product only.

Grey Mill Electrically Driven

The first electrically driven grey mill in this country, and one of the largest mills of its kind in the world, was placed in operation at the Lackawanna plant of the Bethlehem Steel Company early in April. From the standpoint of total horsepower involved, it is one of the most highly powered mills in this country.

The mill consists of three units: (a) a 54-in. reversing blooming mill which is one of the two largest reversing blooming mills in this country; (b) a 48-in. reversing roughing mill, and (c) a 48-in. reversing finishing mill. The rolling schedule covers a full range of Bethlehem beams, girders and columns.

The electric equipment for all the main drives was furnished by the General Electric Company. The 54-in. blooming mill is driven by a d.c. reversing motor rated 7,000 hp. continuously at 40/80 r.p.m. The d.c. for this motor is derived from a fly-wheel motor-generator set consisting of a 5,000 hp., 375 rpm. induction motor, a 50-ton fly-wheel and two 3,000 kw., 750-volt, d.c. generators operated in parrallel.

The roughing mill has two driving motors. The main d.c. reversing motor is rated 7,000 hp., 65/100 r.p.m. 750 vols. The supplementary motor, also reversing, is rated 1,500 hp., 65/225 r.p.m. D.c. for these two motors is supplied by a flywheel motor-generator set consisting of a 5,000-hp., 375-r.p.m. induction motor, a 50-ton flywheel and three 3,000 kw., d.c. generators. Two of these generators are operated in parallel, supplying power to the 7,000-hp. motor, and the other generator furnishes power to the 1,500-hp. motor. The generators are duplicates, in the interests of standardization.

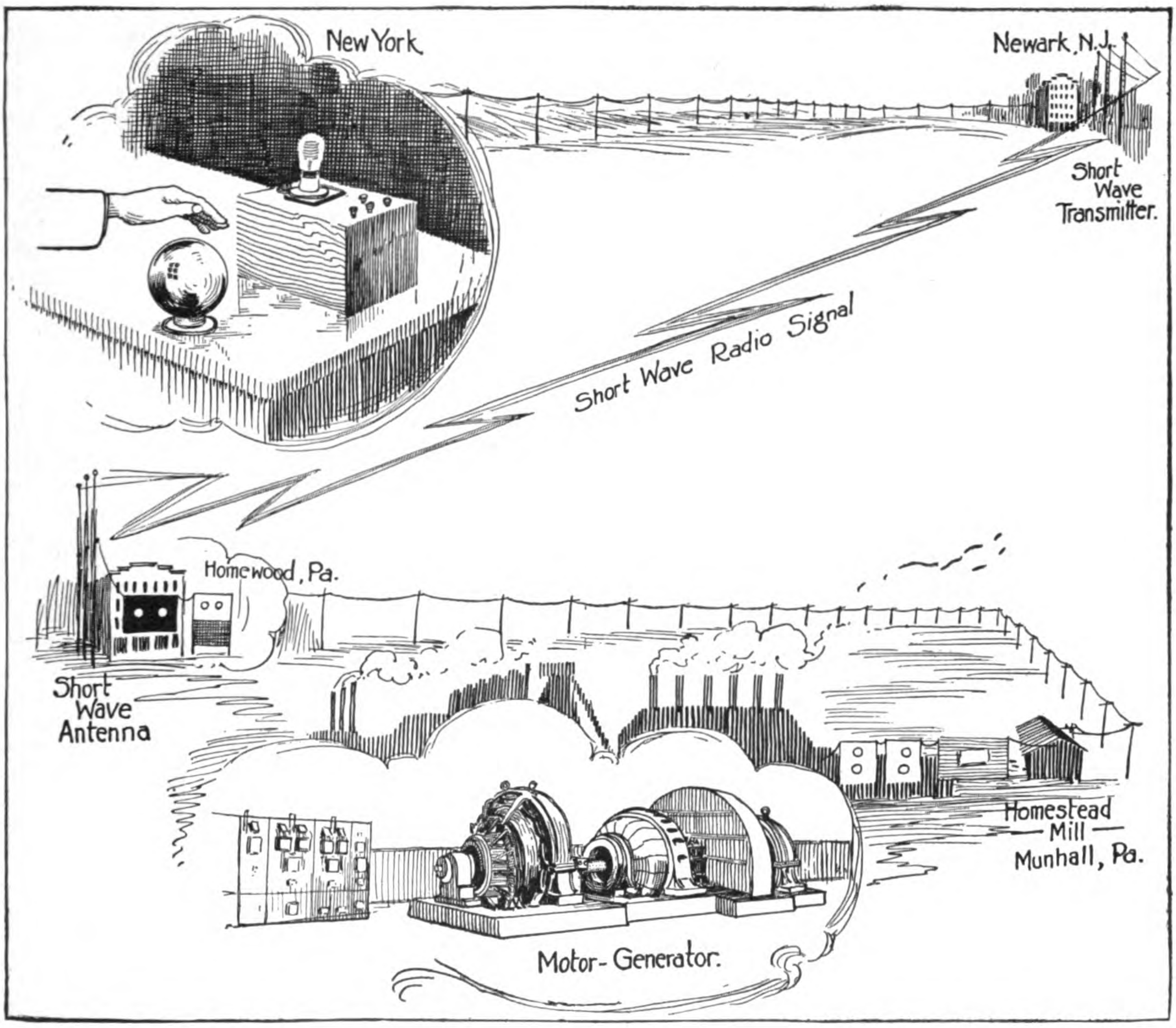
The finishing mill equipment is an exact duplicate of that installed for driving the roughing mill.

Carnegie Structural Mill at Homestead

By Electrical Appliances, Mills at Munhall are Started from New York City. Production of Steel Outlined—Characteristics of Driving Motors Indicates Ample Power

By R. H. WRIGHT*

THE recent feat of starting the newly electrified Homestead mills of the Carnegie Steel Company near Pittsburgh by electrical apparatus functioning at a casual wave of Judge Elbert H. Gary's hand in New York City, brings forcibly to public attention the extent to which electricity has been applied to modern industrial plants.


New York
Newark, N.J.
Short Wave Transmitter.
Short Wave Radio Signal
Homewood, Pa.
Short Wave Antenna
Homestead Mill Munhall, Pa.
Motor-Generator.

The Homestead structural mills represent the most modern steel mill practice and the application of electricity in them is practically universal throughout all departments.

In the electrification of the mills the Westinghouse Electric & Mfg. Company was closely associated with officials of the steel company in the engineering studies made in the planning of the new structural plants and co-operated extensively in the development of the many remarkable electrical features incorporated in their design.

For a number of years we have become accustomed to thinking of our time as the age of steel, and for years the iron and steel industry has been regarded as one of the big businesses of this country. Last year the American production of steel ingots for rolling and forging reached the record figure of over 47,000,000 tons, which is more than 55 per cent of all steel ingots produced in the entire world during that same time. While there is a continual increase in the consumption of steel as measured in tons of ingots, tonnage figures alone do not show the rapidity with which new uses for steel are being found. The art of making alloy steel, which has greater strength than ordinary carbon steel, and the art of heat treating steel to improve its physical properties, while known for years, have been developed to a high degree during the last few years. These processes have materially reduced the weight of many products made partially or entirely of steel without sacrificing their strength and have caused other materials to be supplanted by steel in an increasing number of articles.

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*General engineer, Westinghouse Electric & Mfg. Company.

The automobile is the outstanding example of the use of high steel. Last year American automotive industries took 14½ per cent of all the rolled steel produced in this country. The use of high grade steel and the substitution of light pressed steel parts for parts which originally had been made of heavier castings have been the chief factors in reducing the cost of the automobile. The increasing popularity of steel furniture for home and office use, steel window frames and steel beams for dwellings shows the trend of steel consumption.

Blast Furnace Operation

Blast furnaces use a large amount of electric power. Where the ore is brought in by rail, the loaded cars are picked up bodily, one at a time, turned upside down and the contents dumped out by a huge electrically operated car dumper. If the ore is delivered by boat several electric unloaders are set to work on each boat as it arrives and in a few hours a 10,000-ton boat is unloaded and ready for the return trip. The raw materials are hoisted by electric power to the top of the furnace and at regular intervals a fresh supply is automatically dropped into the furnace without loss of gas through electrically-operated bell-shaped covers. To enable the furnace to withstand the terrific heat in the melting zone near the bottom millions of gallons of cooling water must be supplied daily to each furnace by means of electrically-driven pumps.

At regular intervals the slag and iron are drawn out at the bottom of the furnace into ladle cars. The molten iron is usually hauled directly to the steel plant, where it is refined into steel in open-hearth furnaces of 100 tons capacity. Large plants may have as many as 65 of these furnaces. The open-hearth furnaces are served by electrically operated charging machines and electric cranes by means of which the furnaces are charged and the ladles of molten steel carried away. Molten steel has a temperature of 3,000 deg. F., pours like water and consumes anything with which it comes in contact except strictly non-combustible material. It is poured into ingot molds holding from 6,000 lbs. to 30,000 lbs., depending on the size to which it is to be rolled later. After the molten mass has solidified in the molds, but while the ingots are still red hot, the molds are stripped from the ingots by means of an electric stripping crane. The ingots are then carried to the soaking pits, conveniently located with respect to the rolling mills, where they are heated to a white heat for rolling in the blooming mill.

Electricity for Rolling Mills

Rolling mills have been greatly improved in the last few years and it is here that electricty plays the largest part in the operation of a modern steel plant. Not so many years ago the popular conception of a rolling mill was that of a place where scores of perspiring men, toiling in constant jeopardy of life and limb, fed red hot bars of steel into the whirling rolls. About this same time one was accustomed to see forests of smokestacks each belching forth great columns of flame and black smoke. Above all the roar of the mill was the puff of many steam engines each contributing its share of a mighty cloud of steam which, mingling with the smoke, made a steel plant an awe inspiring sight when viewed from a distance. If one were curious to see the source of the power for all this activity, he would be shown the huge steam engines with their flashing piston rods and cranks and the various boiler houses where tons of coal were being burned hourly to make steam for the ever hungry engines.

The increasing demand for steel made it necessary to provide heavier machinery and made it possible to apply labor saving devices. At the same time the rising cost of fuel made the cost of operating the steam engines prohibitive. Best economy could be obtained by generating all power at a common point instead of having a number of boiler houses each with its standby losses. Because of the waste gas available at the blast furnaces and the ease with which electric power could be transmitted all over the plant with very little loss, an electric power station located at the blast furnaces utilizing the waste gases and supplying power to electrical driven mills was found to be the solution of the power problem.

During the last few years an increasing number of steel plants have been taking advantage of the greatly improved economy obtained through the installation of a complete electric power system with electric motor drive for every rolling mill and accessory in the entire plant. One of the largest rolling mill electrification projects ever undertaken has just been completed at the Homestead Works of the Carnegie Steel Company. This installation is notable because of the number of large electric motors used, on account of the large size of the motors and because of the extent to which automatic labor saving devices have been utilized.

Description of Homestead Mills

The Homestead project involved the complete reconstruction of the department used in the production of structural steel. Seven old rolling mills which, together with soaking pits, furnaces, tracks, yards, shops and miscellaneous equipment, covered 30 acres of ground, were demolished and one huge building, covering 26½ acres of ground under one continuous roof, was erected to house the new mills. Ten thousand car-loads of material including 336 electric motors having a total capacity of 100,000 hp., 61 cranes ranging from 5 to 275 tons lifting capacity, 80 miles of conduit for electric wiring, 30,000 tons of structural steel and 100,000 cu. yds. of concrete were required to complete the project. Although normal production had to be maintained throughout the reconstruction period of two years every unit of the entire project was placed in operation exactly on the date scheduled.

The new mills are divided into two main parts. One group consisting of a 44-in. reversing blooming mill, a 36-in. reversing roughing structural mill and a 28-32-in. three-high, finishing structural mill produces the standard structural shapes formerly rolled in the seven old mills. The second group consists of a 54-in. reversing blooming mill, a 52-in. roughing structural mill, a 52-in. intermediate structural mill and a 52-in. finishing mill. These mills are used to roll special beams for heavy structural work.

Beginning with the soaking pits where the ingots

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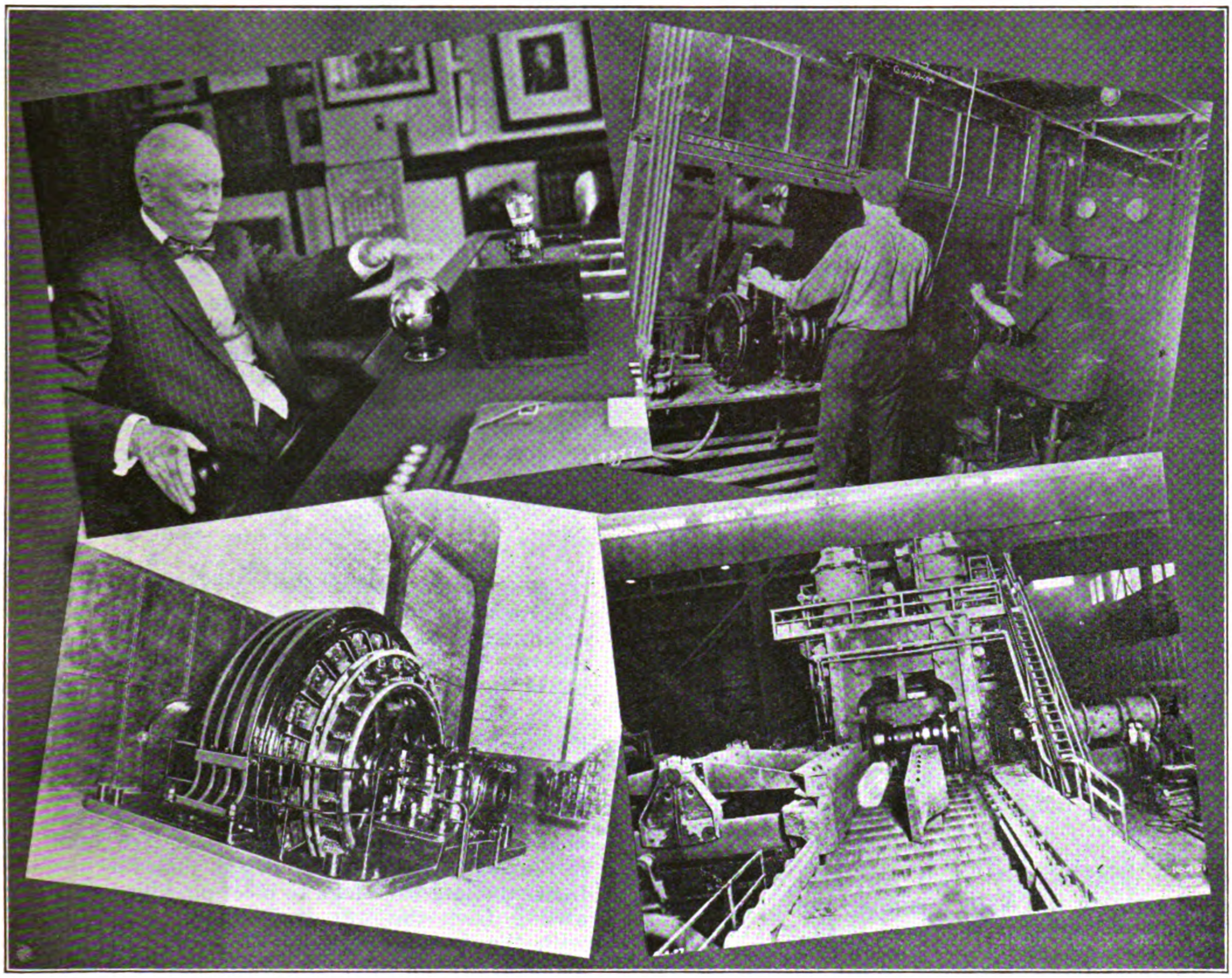
are heated and continuing through to the shipping department for finished materials every mechanical operation in both groups of mills is performed with electrically driven machinery. Some entirely new automatic control features are in use at the soaking pits. The pits, which are a special type of gas-fired furnace each capable of holding a number of steel ingots ranging from 4 to 15 tons in weight, are set in the ground and have motor-operated horizontal sliding covers which just clear the surrounding floor as they are opened and closed. Ingots as they are received on small cars from the open-hearth furnaces are placed in the pits by means of a special crane called the soaking pit crane. This crane has tongs which automatically grip the hot ingot so it can be lifted from the car and lowered into one of the soaking pits. After the ingots have been heated to a white heat they are lifted out of the pits by means of the pit crane and placed on a car which carries them to the blooming mill. By means of special control the operator of the pit crane has complete control over the soaking pit covers and the ingot car, making it possible for one man to do easier and quicker operations which formerly required the efforts of several men.



Upper left—Elbert H. Gary with hand poised over silver-lined sphere. Upper right—Control pulpit for 44-in. reversing blooming mill. The man at the extreme right is the roller and his assistant is at the left of the picture. Lower left—5,000 hp. motor driving 36-in. roughing structural mill. Lower right—View of 54-in. blooming mill. The bloom in the mill weighs almost eight tons.

Path of Ingots

Ingots which are to be rolled to standard structural shapes are delivered to a roller table which leads to the 44-in. blooming mill. In the blooming mill the 8-ton hot ingots are passed back and forth between two huge rolls which are brought closer together after each passage of the glowing metal through the mill. At intervals the bloom is turned over or quickly moved to a different groove in the rolls by an electrically operated manipulator. Power to drive the main rolls comes from a 7,000-hp. reversing motor which can exert 20,000 hp. momentarily. This motor is controlled by means of two foot pedals in the same manager. Two men stationed in an elevated, glass-enclosed pulpit operate the 7,000-hp. motor and all the auxiliary motors required to set the rolls and manipulate the steel.

When the ingot has been rolled down to the desired cross section an electric shear cuts the now red hot steel into blooms of convenient length. An electric charging machine picks up the blooms and places them in reheating furnaces where they are again heated to rolling temperature. The reheated blooms are next given several passes in a 36-in. reversing mill

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driven by a 5,000-hp. reversing motor and are rolled to final size in a 28-32-in. mill driven by a 6,000-hp. induction motor. As the finished beam leaves the mill it is halted momentarily in front of a rapidly revolving circular saw. Here the beam is cut into the desired lengths. The steel is now turned over to the finishing department where each piece, after cooling, is inspected, straightened, sheared if necessary, and finally loaded on cars for shipment. At no time has it been necessary for anyone to touch or handle the steel by hand.

Blooms for the 52-in. structural mills in the second production group which parallels the first group just described are rolled in an immense 54-in. reversing mill. Ingots weighing up to 15 tons can be rolled in this mill. The rolls are nearly 4 ft. in diameter and each roll weighs 40 tons. At each revolution of the rolls 12 ft. of metal passes through the mill. The Westinghouse reversing motor driving the mill is rated 8,000 hp. at 40 rpm. and is the largest single armature electric motor in the world.

This giant motor and all the mill auxiliaries are controlled by two men stationed in the glass enclosed pulpit. Two small foot pedals control the main motor. Orders from the production office are received over a printing telegraph located in one corner of the pulpit. On a small panel beside the roller are the instruments which indicate the power being supplied to the reversing motor and signal lights and push buttons for communicating with the operator in the motor room.

At starting time the roller presses a button, notifying the operator in the motor room to close the circuit breaker which connects the big motor to the generators which supply the power. The signal lights in the pulpit change from green to red when the motor is ready and immediately the roller whistles for a hot ingot. A pit crane lifts out a dripping hot ingot from the soaking pit and sends it along roller tables to the mill. In a fraction of a minute the mill is in operation.

Ingot Converted into Finished Beam

When an ingot leaves the 54-in. blooming mill it has been rolled roughly to the shape of a beam, but much larger in cross section than the finished beam. The spongy waste metal on the ends of the blank is cut off in an electric shear after which the blank goes directly to the 52-in. roughing mill. The steel is shaped by rolling it back and forth several times through the roughing mill, still further reduced by passing several times through the intermediate mill and given final shape by one pass through the 52-in. finishing mill.

The 52-in. roughing and intermediate mills are similar in construction and are of very special design. Each mill has three pairs of rolls. Two pairs of rolls, known as the main rolls, mounted in a heavy steel housing or stand are driven by a 7,000-hp. reversing motor and the third pair, driven by a 2,000-hp. reversing motor, are located in a separate stand very close to and directly in line with the main stand. Since the metal is in both stands at one time it will be evident that, to avoid tearing or buckling of metal, there must be a definite relation between the speeds of the 7,000-hp. and 2,000-hp. motors and this relation must be maintained whether the motors are accelerating, decelerating or running at constant speed in either direction. Special automatic control features have been provided to meet this requirement.

All three pairs of rolls of each mill must be adjusted very accurately for each pass so that all parts of the beam will be elongated equally. The time between passes is very short and the settings must be made very quickly. A very sensitive control scheme, accurate to a few thousandths of an inch sets all three pairs of rolls after every pass.

One man sitting in a swivel chair has 13 operations under his control and easily operates one mill. The 7,000 and 2,000-hp. motors are controlled by the usual foot pedals and the setting of the rolls and the changes in the speed relations of the motors are made automatically for each pass with no thought or effort on the part of the operator other than a slight movement of a single small lever after each pass. Three men control every operation on a beam from the time the blank leaves the bloom shear until it has passed through the three 52-in. mills and the finished beam is delivered to the hot saw. After leaving the hot saw the beam is handled in the finishing and shipping departments in much the same manner as a standard beam.

Power for all the electrified mills in the plant is supplied from a 30,000 kw. steam turbine generating station. This station could supply light and power to an average city of 15,000 population. The combined continuous capacity of all the main roll drives in the new mills is 48,000 hp. In one large motor room, nearly 500 ft. long, are seven motors having a combined capacity of 33,000 hp. and motor generators having a total capacity of 19,200 kw. All this power is controlled by only a few men.

Iron and Steel

Consumption of iron and steel is being maintained at the somewhat lower yet substantial rate of the past four to five weeks. Meanwhile, there is a falling off in unfilled bookings, and a downward tendency in production, with the leading producer at a few points under 90 per cent for the first time in many weeks, and the ingot output for the industry as a whole hovering around 75 per cent.

The general situation, however, continues fundamentally strong. Consumers' stocks are small, even in the case of such companies as took the precaution to accumulate back-logs to meet possible eventualities arising from the soft coal strike. This, combined with the fact that general business is still moving along at a good rate, appears to bear out predictions of at least a good second quarter business in the steel industry.

Structurals and steel bars have been holding up in unexpected good demand, with recent buying of bars at leading centers well ahead of the correponding period of last year. Plates also continue to move better than a year ago. Sheets, on the other hand, are still affected by the uncertainty in the automotive industry, and pipe and other oil country supplies are lagging due to the depression in the oil industry. Domestic freight car buying in April was the slowest this year, amounting to 3,350. However, close to 10,000 cars are now actively pending, which point to an early improvement.

With prices on finished products in general the lowest they have been since the summer of 1922, the recently announced advance in sheets by a number of independent makers proves of special interest.

Continuous Sheet Mill at Ashland

An Outstanding Achievement in the Art of Producing Sheets. Methods Involved Are Explained, from the Casting of the Ingot to the Finished Sheet

By **CHARLES LONGENECKER**

DOWN in its Ashland, Ky., plant the American Rolling Mill Company, in the month of May, rolled 24,000 tons of sheets on a continuous mill. Furthermore, these sheets were rolled direct from ingots weighing 11,000 lb. each, with no reheating of the metal, from a cold state, at any stage of the process. This practice is indeed a radical departure from present day methods, and appears to forecast an eventual readjustment in the art of rolling sheets.

This mill was designed and constructed under the supervision of an engineer whose entire experience was gained with the company, and while a process patent and numerous device patents have been allowed and assigned to the company, the success of this outstanding development as a whole was not due to any one individual, or group of individuals; it was the result of the extraordinary spirit of cooperation which exists in the Armco organization.

The decision, by officials of the American Rolling Mill Company, to erect a mill of the continuous type for the rolling of sheets was reached after very considerable experimenting. The opportunity to do this experimenting was an outgrowth of the war inasmuch as during the latter years of the war restrictions were placed on the operations of those mills rolling sheets. As the mills at Middletown were not in service continually, the company engineers were permitted to carry out experiments by which they could demonstrate the practicability of a theory they had conceived in connection with the continuous rolling of metals. After proving the theory practical the company decided to proceed with the erection of a mill.

In Ashland, there was the plant of the Ashland Iron and Mining Company, consisting of a blast furnace, six open hearth furnaces and a 36-in. blooming mill. This equipment and its arrangement, offered an ideal nucleus around which the proposed mill could be built; accordingly in 1922 the plant was purchased and installation of the additional machinery soon commenced. The mill, in its entirety, was placed in operation during January 1924, in which month the first sheets were rolled.

Since the purchase of the plant, the original equipment has been enlarged and improved; moreover its efficiency has been materially raised by the addition of several accessory appliances. Two blast furnaces and coke plant supply hot metal direct to the open hearth.

The six open hearth furnaces have a capacity of 100 tons each. They receive liquid iron from a 600-ton mixer, which in turn, is supplied from the blast furnace, located about a mile east of the main plant. Both the mixer and furnaces are fired with natural gas, although coke oven gas or fuel oil may be substituted if desired. It was apparent some months after the plant had been in service, that the six furnaces could not supply sufficient steel, as the output of the mill exceeded expectations in the tonnage rolled. This fact necessitated additional furnaces, accordingly two more are now being erected.

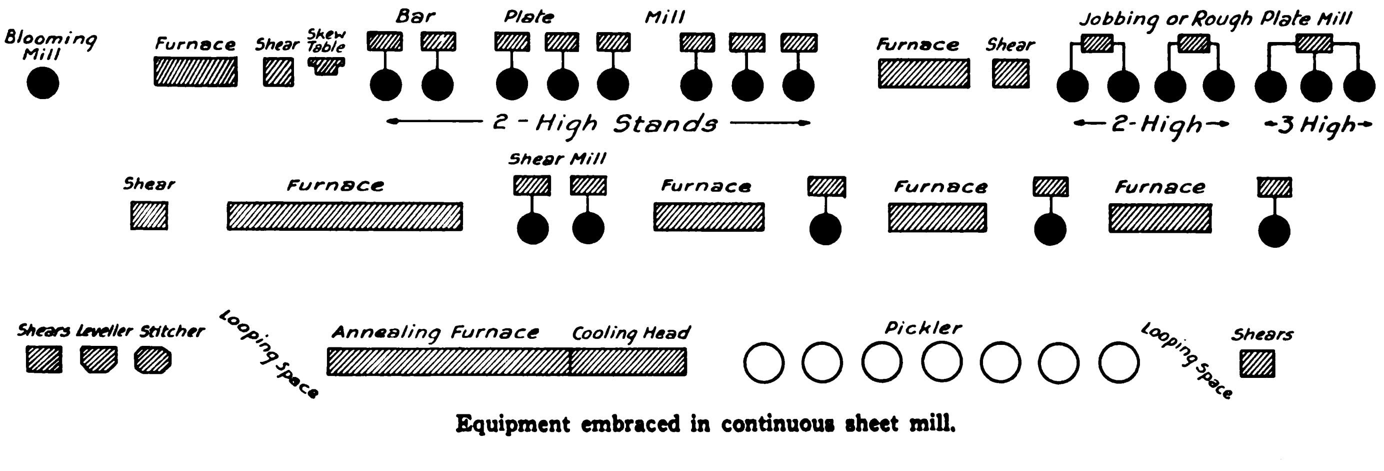
Five 4-hole soaking pits 6 x 8 ft. inside dimensions, equalize the heat in the ingots, as they arrive from the open hearth. These pits can be heated with either natural or coke oven gas.

Blooming Mill

From the soaking pits, the 19 x 39-in. ingots are taken by a chariot to a 36 in. blooming mill and are there rolled into a slab approximately 4 in. thick, 3 ft. wide, and 23 ft. long. This mill, which is electrically driven, has a capacity of from 725 to 1,000 tons in a 10-hour shift.

On leaving the blooming mill the slab passes over roll tables and through a coke gas fired furnace, the function of which is to maintain the temperature of the slab. The furnace, which has a length of 27 ft. 9 in., is equipped with eight rollers in the hearth. Fig. 1 shows the blooming mill, and to the left, the furnace just mentioned.

Following the furnace a 6 x 36-in. shear has been placed, underneath of which is a conveyor for carrying away the crop ends of the slab. Here the slab is



Equipment embraced in continuous sheet mill.

sheared into lengths appropriate for the size of bar to be rolled.

Bar Mill

In what is termed the bar mill, there are seven stands of 2-high, 30 x 58 in. balanced rolls, with vertical edgers after the second and fourth stands. A third vertical edger will be installed.

The motors and speeds in the seven mill drives are:

Mill	Motor		Mill speed
No.	hp.	r.p.m.	r.p.m.
1	300	585	14
2	300	585	20
	Edger driven from above drive		
3	300	585	25
4	500	585	25
	Edger driven from above drive		
5	500	585	25
6	600	870	36
7	600	870	36

Reduction gears are placed between the motors and mills.

Entering the first of these mills, with a thickness of 4 in., the slab is reduced to approximately 7/16 in. These seven stands are operated by four men: a roller, a roller's helper, a stand operator and a man in the control room. In Fig. 2 the bar mill is seen from the exit end.

The product of the bar mill either passes on for further reduction, or is carried over a transfer table and placed in a storage yard. "Armco" skelp for conversion into pipe comes from this mill. In the production of "Armco" ingot iron it is imperative that the metal be rolled either below, or above, the "critical" temperature, but never at this temperature. This condition necessitates a control of temperature as the piece proceeds through the various mills. At the end of a roller table 141 ft. long the piece enters a holding furnace.

On emerging from the furnace the plate is sheared by a ½ x 45-in. shear into suitable lengths for rolling on the "jobbing" mill. The shear is manually operated, hence it can be quickly adjusted to deliver any length needed. Crop ends fall into a bucket directly beneath the exit side of the shear.

Jobbing Mill

Seven mills constitute the jobbing mill. Four of these mills are 2-high, with balanced rolls, 30 x 58 in., while the other three mills are 3-high with rolls, 30 x 14 x 58 in. The drive for these mills consists of two

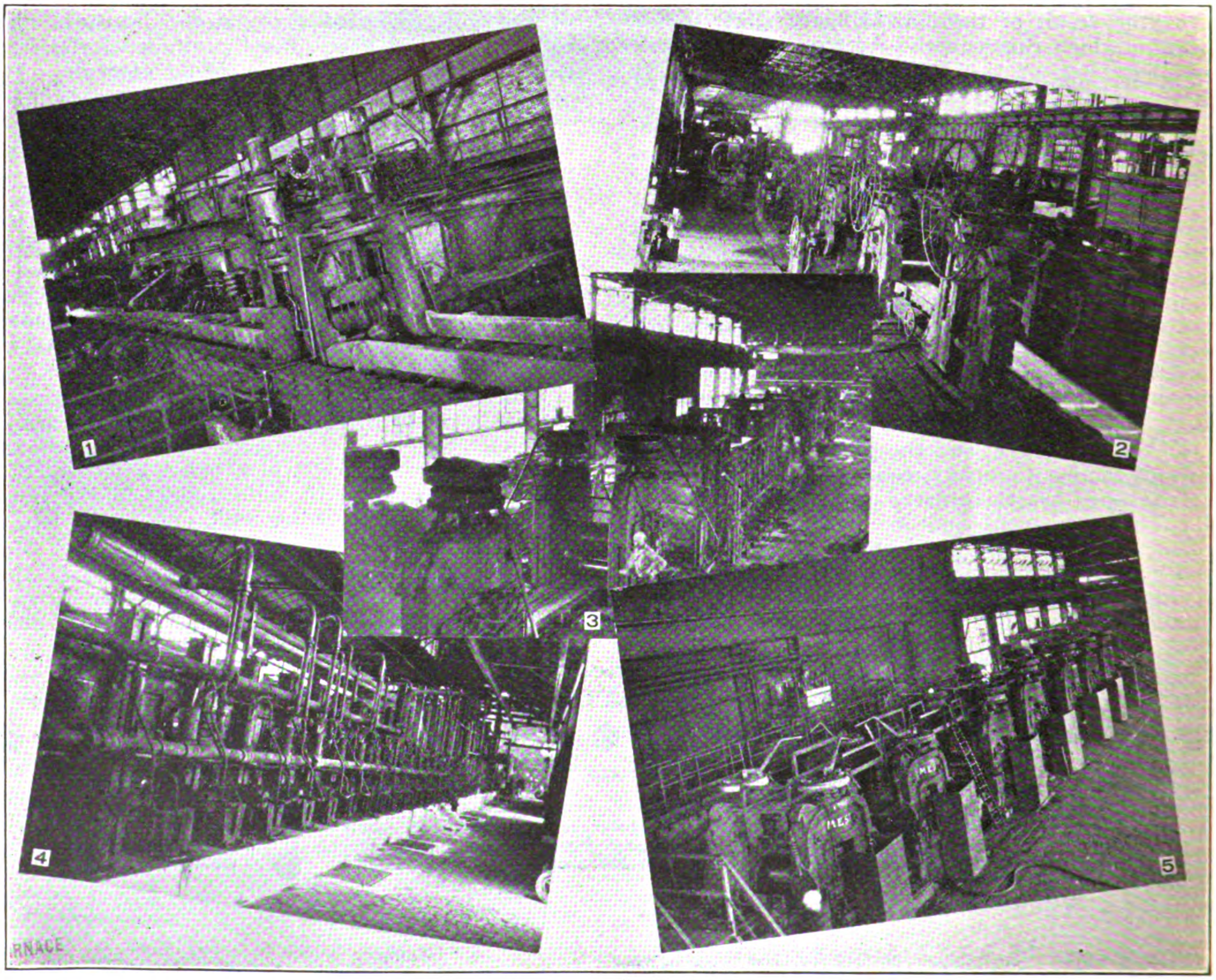


FIG. 1—Electric driven blooming mill where the ingot is made into a slab. FIG. 2—Second rolling operation, slab to bar plate. FIG. 3—Rolling bar plate to 16 gauge. The five-ton ingot is now a 16-gauge sheet. FIG. 4—Continuous furnace for lighter gauge sheets. FIG. 5—Rolling to lighter gauges. The ingot is now a 20-gauge sheet.

2,000 hp. induction motors and one 1,800 hp. induction motor. Each 2,000-hp. motor, driving two mills, transmits its power through a primary speed reducer and from this through a secondary reducer with two low-speed shafts. The 1,800 hp. motor drives the three last mills. In this latter instance the power passes from the primary reducer into a secondary reducer which is equipped with three low-speed shafts. The speeds of the mills, in the order of their position in the line of progress of the plate are, 45 rpm. for Nos. 1 to 4, and 43.2 to 64.6 rpm. for No. 5, 51 to 66.5 rpm. for No. 6, and 57 to 85 rpm. for No. 7. In these mills the piece is reduced to No. 16 gauge and has a width of about 45 in. Eleven men operate this mill. In Fig. 3 the seven mills are shown with the motor room and control operator in the background. When the piece leaves the last set of rolls it is conveyed to a "pinch roll" by a "run-out table" and is then delivered to the "matching table." This table is equipped with a "Weightograph" the function of which is to weigh each plate and thereby determine its gauge. Ultimately a mechanical packer will be installed with this scale. After weighing the plate it is passed on to a disc table which transports it to the warehouse where it is pickled, annealed, or carried to the sheet mill.

Jobbing Mill Warehouse

This warehouse is traversed by cranes of 15-ton capacity with a span of 113 ft. 2½ in. Pickling tanks and annealing furnaces are located in adjacent buildings, but are so placed as to be convenient for service. Before any plates are delivered to the sheet mill they are pickled and end sheared by shears which are so constructed that both ends of the piece are cut by blades moving in unison. The lightest gauge of plates as they come from the jobbing mill is No. 16, while the heaviest is No. 6.

Underlying Principle in Continuous Rolling

In the fore part of this description, mention was made of experiments which had been performed at the Middletown plant in connection with the continuous rolling of sheets.

A number of experiments were made to outline the scope of the problem. Idle mills during the late war gave opportunities for further experiments. The fundamentals of rolling sheets had to be discovered and the control of these fundamentals invented.

As the investigation progressed it was shown that almost infinitesimal measurements, running in ten thousandths of an inch, had a profound influence on the finished product. The problem was further complicated by the fact that when a sheet passes through a pair of rolls, the conditions are changed from those which exist without a sheet in the rolls. New terms were necessary to adequately describe the conditions. The term "active pass" was adopted to describe the space between the rolls while they are in engagement with the piece being rolled there between. It was also necessary to make measurements of temperatures of revolving rolls as well as the material being worked upon and also the sizes of rolls in figures that were not previously considered significant.

It was the universal belief up to that time that in order to successfully roll sheets, the rolls, while the sheet is passing through, had to be as nearly a true cylinder as possible. On the contrary it was learned that a true cylinder cannot possibly roll wide, thin sheets.

The analysis of the old Welsh process showed that the active passes were not always such that the rolls were truly cylindrical. Although the practices of rollers in the rolling of sheets was performed by tradition on but one set of rolls which were supposed to give their particular shape to the piece or pack, it was discovered that the best controlled active passes were those in which the shape of the piece in the active pass was different from the shape of the piece before entering the pass.

The discovery led immediately to the system of control which has removed to a large degree the limitations in width and thinness, which had formed the stopping place of continuous rolling processes of the past.

Like other departures in industry, the thing is simple, once you know it. The basis of the new developments lies in the control of the various factors going into the formation of the active pass so that a piece is rolled with a slight convexity and makes the piece more parallel surfaced.

The problem of using side guides to feed a thin, wide piece of metal, is done away with by this control, because the rolling of slight convexity into the piece, which is preserved but reduced in each pass, forces the piece to travel through the roll stand in a straight line, as if in a closed pass. With truly cylindrical active passes, the piece will tend to travel toward the necks in a manner which side guides are completely inadequate to control, due to the thin, wide nature of the product being formed.

In the rolling of narrow strips on a strip mill, there is little difficulty in guiding the material, but as the width of the sheet increases these difficulties become much greater, a fact which those who have endeavored to roll wide, thin sheets in the past have found to their discouragement.

The Ashland development of The American Rolling Mill Company was based upon the composition, size, surface, and shape of the rolls, as well as the temperature controls on the rolls, the pieces being rolled, and the screw control on the rolls, followed along mathematical lines, once the factors were known, and the control process discovered.

With the new problems, it was possible to work out new mechanisms for handling the material.

Sheet Mill

Plates that are to be rolled into sheets are delivered from the warehouse and are placed on a short roll table which carries them to a continuous furnace 140 ft. long, a photograph of which is shown in Fig. 4. In passing through this furnace the plates rest on discs mounted on water cooled shafts. Fig. 5 shows the sheet passing from the first to the second mill. These mills, as is plainly seen, are three high with 30 x 58-in. top and bottom rolls, and a 14 x 58-in. middle roll. Mills Nos. 2, 3, and 4 are followed by continuous furnaces, but in these the sheets rest on "fingers" carried on an endless chain supported by discs. Each mill is driven at a speed of 25 rpm. through a speed reducer, by a 300 hp. motor with the exception of No. 5 mill to which a 400 hp. motor is attached.

The sheet coming from the last hot mill is now to gauge and of the desired width but before under-going any further treatment must be sheared to size. This is accomplished by trimming the sides on a rotary shear and cutting off the ends on shears arranged in tandem.

Up to this point the methods of handling has been confined to equipment which, while novel in detail and arrangements possessed, in general, features conforming to that found in other plants. But here a distinct innovation in procedure is introduced. Instead of adhering to customary practice and treating each sheet separately, the sheets are formed, for future handling, into a long ribbon by a machine which is termed a "stitcher." Four of these machines are shown in Fig. 6. In Fig. 7 the stitches joining the sheets can be seen. The sheets are "stitched" in one movement of the machine and then, passing forward, are looped over large pulleys from which they are drawn into the normalizing furnace as illustrated in Fig. 7. By forming loops enough play is secured to avoid any stretching of the ribbon in its passage through the furnace and subsequent apparatus. Pyrometers, inserted at frequent intervals, record any variation in temperature from that desired.

On leaving the normalizing furnace the ribbon of sheets is protected from oxidization by being confined in a cast-iron brick-lined hood which extends from the outlet of the furnace to a point near the pickling tanks.

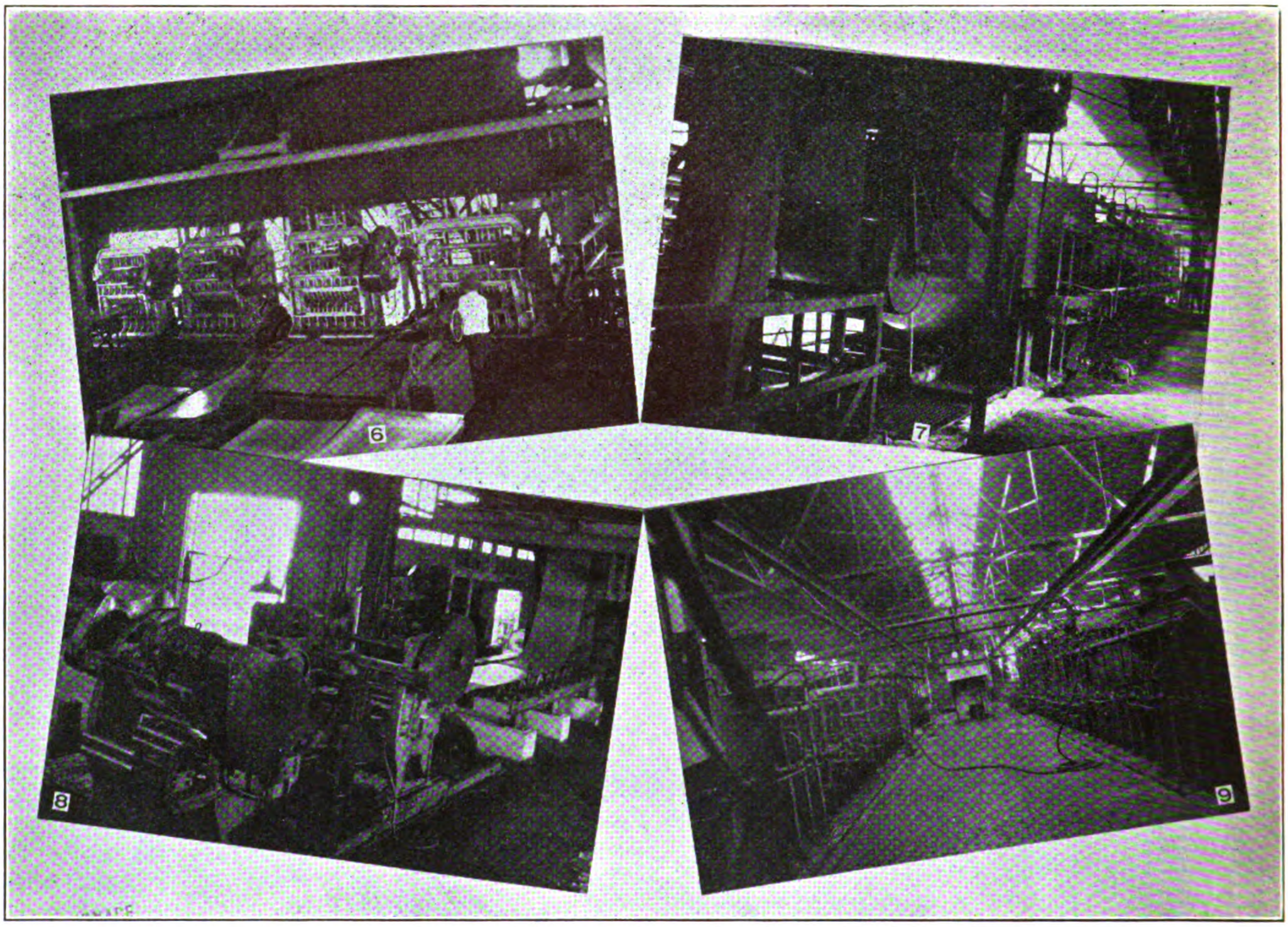


FIG. 6—Stitching the sheets into a continuous ribbon for further proceeding. FIG. 7—The ribbon of sheets entering a continuous annealing furnace. FIG. 8—Cutting stitches out of the sheets after annealing and pickling. FIG. 9—The battery of annealing furnaces where every sheet is heat-treated with precision.

Pickling is effected by looping the sheets successively into nine lead-lined pickling tanks, some of which contain a dilute solution of sulphuric acid. After emerging from the pickling vats the ribbon descends, as can be seen in Fig. 8, to a disc roll table from which it enters a machine for the renewal of the stitches. As the sheets are now to size they are passed on to the cold rolls of which there are eight trains, of from two to five mills each. The rolls in these mills are 26 x 56 in. and have a speed of 30 rpm. They are driven by 300 and 400 hp. motors which transmits their power through single reduction speed reducers. These mills are located in a building with its crane runway at a right angle to that of the building from which the sheets are delivered. On the side of the building opposite that through which the sheets are received access is had to three continuous box annealing furnaces. A transfer car which moves on a track in front of the furnaces provides means for shifting the loaded cars to or from any one of the three furnaces. Each furnace will accommodate 12 cars, carrying 30,000 lb. of sheets apiece. Two of the continuous furnaces are shown in Fig. 9. An elaborate system of pyrometer control assures the maintenance of a uniform and definite temperature throughout the furnace.

Not far from the cold rolls is located the field

(Continued on page 346)

The Gas Permeability of Refractory Brick*

Porosity of Brick Is Determined Largely by Methods of Manufacture—Flow of Gases Through Brick Should Be Prevented—Affect of Various Coatings Described

By F. A. WICKERHAM†

PART II

IF the permeability of the same kind of bricks of different thicknesses was in proportion to the thickness of the brick, thickness of walls in furnace construction would be a very important consideration in the prevention of heat losses due to leakage of gas through the bricks.

Tests were made on bricks of different thicknesses, but of the same kind, as shown in Table F.

Considerable variation is shown in the permeability of bricks of any given thickness in both the silica and fire clay brick. Making allowance for this lack of uniformity, the averages for the silica brick are close to being in the proportion of the square roots of the thicknesses.

The fire clay bricks gave contradictory results. The average time is approximately the same for the 1¼ in. thick bricks as for 2½ in. thick bricks of the same brand. As the raw material was the same in both cases, the pressure in repressing and the better penetration of the heat in burning the 1¼-in. bricks has aparently had a greater influence than the difference in thickness of the bricks.

Relative Permeability of Different Kinds of Heat Insulating Bricks

The permeability to gases is usually not considered in heat insulating brick. Two different kinds of brick may be equally good heat insulators in preventing loss of heat by conduction, but when the heat is in contact with the brick in the form of hot gases, one brick may give much poorer results than the other on account of its greater permeability.

A series of tests were run on a number of different brands of heat insulating bricks. In most cases the number of bricks available for test was limited to one or two specimens. Table G gives the results for these bricks. All results are the averages of duplicate tests made on the same brick.

These results show that there is a great difference in the gas permeability of different insulating bricks, consequently, the heat conductivity of the brick alone is not a true index of the value of the brick, unless the manner in which the heat is communicated be known. As an example, the heat conductivity may be the same for bricks "E" and "F" from manufacturer "P," but gas will pass through brick "E" almost six times as fast as through brick "F." A great difference is also found in some bricks of the same brand, for instance, in brands "G" and "H" one brick permits air to pass through approximately four times as fast as the most impervious brick of the same brand.

Effect of Mortar at the Joints

The bricks used in a wall may be impervious to gas, but unless the joints between the bricks are as good as the bricks there will be leakage of gases at the joints. A study was made of the ability of mortar to resist passage of gas by molding standard 9-in. bricks from mortar such as was used in laying the brick, allowing it to become dry and then testing for permeability.

A number of samples were made in this manner and then dried at 100 deg. C. The samples were then tested in the same manner as standard 9-in. bricks. All of the samples were impervious to air at 1 lb. pressure.

TABLE F

Relative Permeability of Fire Clay and Silica Bricks of Different Thicknesses

		Time in Seconds for 1 cu. ft. of Free Air to Pass Through 1 sq. in. of Exposed Surface of Brick	
Kind of Brick	Thickness	1 lb. Pressure	½ lb. Pressure
Silica Brick	1¼" Thick	103	192
Silica Brick	1¼" Thick	114	231
Silica Brick	1¼" Thick	158	315
Silica Brick	1¼" Thick	154	310
Average................		132	262
Silica Brick	2 " Thick	127	257
Silica Brick	2 " Thick	161	319
Silica Brick	2 " Thick	180	378
Silica Brick	2 " Thick	153	303
Silica Brick	2 " Thick	154	319
Average................		155	315
Silica Brick	2½" Thick	161	321
Silica Brick	2½" Thick	154	300
Silica Brick	2½" Thick	157	319
Silica Brick	2½" Thick	232	467
Silica Brick	2½" Thick	238	476
Average................		188	375
Silica Brick	3 " Thick	219	440
Silica Brick	3 " Thick	188	378
Silica Brick	3 " Thick	241	480
Silica Brick	3 " Thick	211	420
Silica Brick	3 " Thick	214	425
Average................		215	429
First Quality Fire Clay Brick	1¼" Thick	1361	...
First Quality Fire Clay Brick	1¼" Thick	1483	...
First Quality Fire Clay Brick	1¼" Thick	1044	...
First Quality Fire Clay Brick	1¼" Thick	902	...
First Quality Fire Clay Brick	1¼" Thick	1041	...
Average................		1166	...
Same Brand Fire Clay Brick	2½" Thick	1525	...
Same Brand Fire Clay Brick	2½" Thick	1176	...
Same Brand Fire Clay Brick	2½" Thick	734	...
Same Brand Fire Clay Brick	2½" Thick	1038	...
Same Brand Fire Clay Brick	2½" Thick	1378	...
Average................		1170	...

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*Paper read before the American Iron and Steel Institute, at New York, May 20, 1927.

†Assistant, Central Research Bureau, Carnegie Steel Company, Pittsburgh, Pa.

To more nearly imitate service conditions, bricks were laid together with an ⅛-in. joint of mortar between them. Tests made, after the mortar had been thoroughly dried, by placing the funnel opening directly over the joint indicated that 1 cu. ft. of free air required two to three times as long to pass through 1 sq. in. of exposed surface at the joint as it did to pass through the bricks on either side of the joint.

TABLE G

Relative Permeability of Heat Insulating Bricks

Brand	Brick Manufacturer	Time in Seconds for 1 cu. ft. of Free Air to Pass Through 1 sq. in. of Exposed Surface of Brick 1 lb. Pressure	½ lb. Pressure
Insulating Brick—A	M	957	1920
Insulating Brick—A	M	1270	2547
Insulating Brick—B	M	Impervious	Impervious
Insulating Brick—C	N	Impervious	Impervious
Insulating Brick—C	N	Impervious	Impervious
Insulating Brick—D	O	105	223
Insulating Brick—E	P	90	181
Insulating Brick—F	P	532	1017
Insulating Brick—G	R	....	5567
Insulating Brick—G	R	....	9999
Insulating Brick—G	R	....	6040
Insulating Brick—G	R	....	20151
Insulating Brick—H	R	....	613
Insulating Brick—H	R	....	1137
Insulating Brick—H	R	....	2631
Insulating Brick—H	R	....	1202
Insulating Brick—L	S	....	229
Insulating Brick—L	S	....	294
Insulating Brick—L	S	....	297
Insulating Brick—L	S	....	257
Insulating Brick—L	S	....	274

These joints were also tested by passing by-product coke oven gas through the adjoining bricks and the joints instead of air. The gas escaping on the opposite side was ignited to show whether the gas was passing through the mortar or the bricks. Four different sets of tests made in this manner showed that none of the gas escaped through the mortar, but that it was all passing through between the mortar and the adjoining bricks, or through the bricks themselves.

These tests indicate that joints between bricks that are well filled with dried but not burned mortar are less permeable to gases than first quality refractory bricks ordniarily used in the construction of furnace walls and flues.

Permeability to Gases Other than Air

The gases available for test were by-product coke oven gas, commercial hydrogen, carbon dioxide, butane and acetylene. Tests made by passing these gases through different bricks are shown in Table H.

The by-product coke oven gas used had a density of approximately .33 with air at unity. The densities generally given for the other gases when pure are:

Acetylene	.91
Hydrogen	.069
Carbon Dioxide	1.53
Butane	2.07

While the gases used in these tests were not pure gases, besides containing more or less water vapor by being confined in the gasometer, it is evident from the results that the time for a given amount of gas to pass through a brick bears no relation to the density of the gas. This is in accordance with the findings of Bunsen and other investigators, who have proven that the flow of gases through a porous material depends more upon the physical character of the gas than it does upon the density.

Permeability at Elevated Temperatures

The apparatus for testing the permeability of bricks to gases at temperatures higher than room or normal temperatures is shown in Fig. 5.

The same gasometer "G" was used as with tests at normal temperatures. The brick was held rigidly in place over the funnel opening by clamp "A" and was surrounded by a coil of pipe "C," which was connected by a small tube to the gasometer.

The coil, with brick in place, was set in molten tin heated to the desired temperature. The tin was of sufficient depth to completely cover the coil and to cover the sides of the brick almost level with the face, acting as a seal to prevent the escape of gas except through the uncovered face of brick. An asbestos washer was placed between the funnel and the brick, and the funnel sealed around the edges with quick-setting cement.

The molten tin was maintained at a temperature 491 deg. F. higher than room temperature, or a temperature at which the volume of gas would be approximately doubled and its density correspondingly decreased, when there was no change in pressure.

Tests were made by passing the gases through the coil and exhausting them into the atmosphere through a small orifice instead of through a brick. When a cubic foot of gas, measured at normal temperature as it came from the gasometer, was raised 491 deg. F. in passing through the coil, it required slightly less than twice as long to escape into the atmosphere as it did when passed through the coil without heating. This showed that the volume of gas passing out the orifice had been approximately doubled.

In testing bricks, the coil with brick in place was set in the molten tin and allowed to remain until the brick was heated throughout, then tested with the different gases. As the apparatus used in this test differed materially from that used in making the studies with gas at normal temperatures, all tests made at temperatures 491 deg. F. higher than room temperature had to be duplicated at room temperature to secure results that were comparative. This was accomplished by allowing the brick and coil to re-

TABLE H

Permeability of the Same Bricks to Different Gases

Kind of Gas	Kind of Brick	Time in Seconds for 1 cu. ft. of Free Gas to Pass Through 1 sq. in. of Exposed Surface of Brick 1 lb. Pressure	½ lb. Pressure	¼ lb. Pressure
Silica Brick	Air	238	478	952
Same Brick ...	By-product coke gas	157	315	629
Same Brick ...	Butane cutting gas	140	283	504
Silica Brick	Air	194	386	759
Same Brick ...	Butane cutting gas	112	216	409
Same Brick ...	Acetylene	117	228	442
Same Brick ...	Hydrogen	95	197	395
Same Brick ...	Carbon dioxide	172	338	646
Fire Clay Brick..	Air	536	1064	2107
Same Brick ...	By-product coke gas	349	692	1356
Same Brick ...	Butane cutting gas	361	634	1161
Same Brick ...	Acetylene	357	666	1203
Same Brick ...	Hydrogen	257	512	1034
Same Brick ...	Carbon dioxide	504	975	1713

main in the tin overnight until it solidified and cooled to room temperature. When tested the next day with gas at room temperature, the sides of the brick were effectively sealed by the solidified tin, and gas could be passed through the brick in the same manner as when heated. Duplicate tests were made in each case, the results checking within a very few seconds.

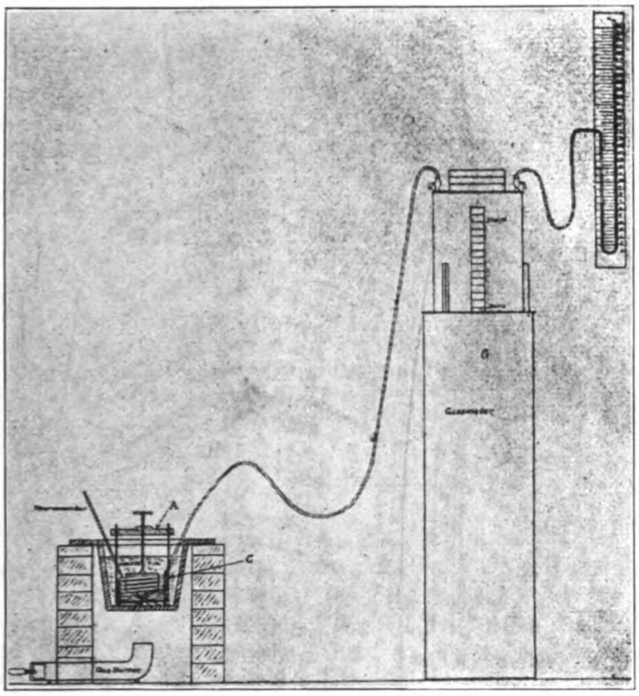

FIG. 5—Apparatus for determining permeability of bricks to gases at elevated temperatures.

Table I shows the actual time required for 1 cu. ft. of the different gases, as measured at the gasometer, to pass through the coil and brick.

The time required to pass 1 cu. ft. of gas from the gasometer through the coil and brick at different pressures is not as close to the inverse ratio of the pressures as in the former tests in which the gas was passed direct from the gasometer to the brick. As this was true with tests made with the coil, both at room and higher temperatures, the friction of the gas in the coil has apparently been responsible for the difference.

It required almost twice as long for 1 cu. ft. of gas to pass from the gasometer through the heated coil and brick as it did at room temperature. This showed that the volume of gas had been doubled by raising the temperature 491 deg. F. above room temperature.

On the basis of the same volume of gas passing from the brick into the atmosphere, it required less time for 1 cu. ft. of the heated gas to escape than it did for the same volume of gas at room temperature. This indicates that when the bricks and gas are in a heated condition, as would be the case in service, more gas will pass through the bricks when hot than when cold.

The time required for 1 cu. ft. of gas to pass through the bricks, either hot or cold, did not bear any relation to the density of the gases. This confirmed the previous tests made with different gases at room temperatures.

Prevention or Reduction of the Flow of Gases Through Bricks

It has been shown that the various bricks ordinarily used in the construction of industrial furnaces are more or less permeable to gases. The problem now becomes one of how the bricks may be rendered impermeable to gases, or how the leakage of gases through the bricks may be reduced.

Reduction of heat losses due to leakage of gases through bricks may be accomplished in one of three ways:

1—Coatings applied to the bricks or wall which will prevent escape of gases through the brick.
2—Changes in the present method of manufacturing the brick.
3—Substitution of less permeable bricks for bricks now being used.

A series of tests were made to determine the effectiveness of various coatings that might be applied to bricks to reduce the permeability. The tests covered sodium silicate, whitewash, ordinary fire clay mortar, quick setting cement, and different mixtures using tar as a base.

As silica bricks are very permeable, most of the studies of coatings were made with silica brick, as results could be obtained in a shorter time, and it was safe to assume that if a coating would reduce the permeability of silica bricks, other bricks would be affected in like manner. Some tests, however, were carried out on fire clay brick to obtain additional information.

Whatever means may be adopted, it must be capable of practical applications. Coating the outer surface of a brick with paraffin renders the brick impermeable at normal temperatures. Where temperatures

TABLE I
Actual Time Required to Exhaust One Cubic Foot of Gas from Gasometer and Pass Through Coil and Brick

		Actual Time in Seconds to Exhaust 1 cu. ft. of Gas From Gasometer and Pass Through Coil and Brick					
		Gas at Room Temperature			Temperature Raised 491 deg. F. Above Room Temperature		
Kind of Brick	Kind of Gas	1 lb. Pressure	½ lb. Pressure	¼ lb. Pressure	1 lb. Pressure	½ lb. Pressure	¼ lb. Pressure
Fire Clay Brick	Air	680	1300	....	1258	2166	....
Same Brick	Commercial hydrogen	347	665	....	600	1322	....
Same Brick	Commercial carbon dioxide	659	1213	....	1196	2221	....
Same Brick	By-product coke gas	449	851	....	875	1514	....
Fire Clay Brick	Air	1351	2577	....	2548	4845	....
Same Brick	Commercial carbon dioxide	1259	2256	....	2290	3810	....
Silica Brick	Air	326	613	1157	627	1215	2332
Same Brick	By-product coke gas	208	411	741	410	815	1521
Silica Brick	Air	313	597	....	608	1188	....
Same Brick	By-product coke gas	198	386	....	391	760	....

are high, there would be danger of the paraffin igniting and burning out, or being volatilized and its effect on permeability destroyed.

Sodium silicate is another material that will render a brick impermeable to gas when the brick is in a cold condition. It can be applied to walls by means of a spray or by a brush. Under heat the coating will gradually lose its effectiveness and will have to be renewed at frequent intervals.

Whitewash has certain advantages. It is cheap and can be easily applied by brush or spray. It would also serve to brighten or light up places that are otherwise very dark. The disadvantages are that it cracks and peels off under heat and is not very effective in reducing permeability.

Coating a brick wall with ordinary fire clay mortar has the advantage that the coating can be easily applied. It has the serious disadvantage that the mortar cracks in drying, and there is a tendency for part of the mortar to fall off, particulary when subjected to heat.

The cracking of fire clay mortar in drying can be prevented to a great extent by mixing certain proportions of sodium silicate and sand with the ordinary fire clay mortar. This material sets much harder than regular fire clay mortar, and adheres to the brickwork much better. Cracking is not entirely eliminated by the addition of sodium silicate and sand to the mortar, but the results with a well applied coating of such mortar recommends its use.

Tar is another material that has the advantage of being cheap, and can readily be applied to walls by brush or spray. It is objectionable on account of burning off at higher temperatures, and its tendency to dry out or coke and lose its effectiveness under heat. At best, when tar is used alone for coating bricks, it only serves to reduce the permeability at normal temperatures.

Tar mixed with other materials such as graphite, fire clay, asbestos, etc., to give it body, offers certain advantages. The mixed material, in the form of a paste, can be applied with a trowel. When used where temperatures are low, the mixtures greatly reduce the permeability of the bricks, one particular mixture rendering both fire clay and silica bricks impervious to gas when tested in the cold condition.

The results of tests of bricks coated with various materials are given in Table J.

All the coatings tried reduced the permeability of the bricks when used at normal temperatures. The mixtures having a tar base, as a whole, gave better results than other coatings when tested cold. When the same mixtures were tested with gas and brick at a temperature of about 550 deg. F., the bricks coated with a tar base material, which were impervious at room temperatures, soon offered little greater resistance to the passage of gas than the uncoated brick. The coated bricks at first would be impervious to the gas, but as the tar base coating dried out and became more coke-like in character, the permeability gradually increased, showing that coatings of this character, at higher temperatures, had little value as a permanent protection against leakage of gas.

Since none of the coatings can be said to be satisfactory, the next step was to consider the possibility of reducing the permeability of bricks by changes in the present methods of manufacture.

The great variation in the permeability of bricks of the same kind shows that one of the remedies must necessarily be the production of bricks that are more uniform in character. If some bricks of a certain kind are fairly impervious and others from the same shipment or lot permit the passage of a considerable amount of gas, the manufacturers' problem is to make all bricks of the same kind equally impervious.

TABLE J
Effect of Various Coatings on Permeability of 2½-inch Bricks

Kind of Brick	Kind of Coating	Time in Seconds for 1 cu. ft. of Free Air at ½ lb. Pressure to Pass Through 1 sq. in. of Exposed Surface of Brick	
		Uncoated Brick	Coated Brick
Silica Brick—A	Whitewash	180	383
Silica Brick—B	Whitewash	190	448
Silica Brick—C	Whitewash	178	408
Silica Brick—D	Whitewash	184	419
Silica Brick—A	Ordinary Fire Clay Mortar	176	579
Silica Brick—B	Ordinary Fire Clay Mortar	182	435
Silica Brick—C	Ordinary Fire Clay Mortar	202	568
Silica Brick—A	Fire Clay Mortar Mixed with Sodium Silicate and Sand..	194	951*
Silica Brick—B	Fire Clay Mortar Mixed with Sodium Silicate and Sand..	187	958*
Silica Brick—C	Fire Clay Mortar Mixed with Sodium Silicate and Sand..	218	Impervious
Silica Brick—D	Fire Clay Mortar Mixed with Sodium Silicate and Sand..	180	Impervious
Silica Brick—A	Heavy Coating Sodium Silicate	190	Impervious
Silica Brick—B	Heavy Coating Sodium Silicate	232	Impervious
Silica Brick—A	1 coat of Tar	200	780
Same Brick—A	2 coats of Tar	200	1222
Silica Brick—B	1 coat of Tar	188	708
Same Brick—B	2 coats of Tar	188	1193
Silica Brick—C	1 coat of Tar	167	662
Same Brick—C	2 coats of Tar	167	962
Silica Brick—A	Tar and Kish	190	1535
Silica Brick—B	Tar and Kish	174	1603
Silica Brick—C	Tar and Kish	172	2286
Silica Brick—D	Tar and Kish	186	2126
Fire Clay—A .	Tar and Kish	1050	Impervious
Silica Brick—A	Tar and Fire Clay	220	3834
Silica Brick—B	Tar and Fire Clay	178	2426
Silica Brick—C	Tar and Fire Clay	188	2489
Silica Brick—D	Tar and Fire Clay	198	2142
Silica Brick—A	Tar, Asbestos and Graphite	210	Impervious
Silica Brick—B	Tar, Asbestos and Graphite	195	Impervious
Fire Clay—A .	Tar, Asbestos and Graphite	1224	Impervious
Fire Clay—B .	Tar, Asbestos and Graphite	1190	Impervious

*Coating had a number of fine cracks formed in drying.

Since silica, chrome or magnesite bricks cannot be vitrified in manufacturing without destroying their properties, little improvement can be expected in the permeability of these bricks, except the slight improvement that may be obtained by making these bricks more uniform in character.

Each of these three varieties of bricks possess particular and distinctive properties that make their use desirable under certain conditions. For this reason, the substitution of a less permeable brick of another kind for silica, chrome or magnesite brick is, with a few exceptions, not practical. An outer course of vitrified clay bricks is impractical in most places where any of these three kinds of bricks are ordinarily used, as the covering would hold the heat and cause the fusion of the inner courses of brick. A thin slurry of special mortar would decrease the flow of gases, but the benefit at the high temperatures would be small.

The process used in making first quality fire clay bricks has been shown to have a pronounced effect on the gas permeability of the bricks. Hand made bricks are the most permeable, and well made auger machine repressed bricks are the most impervious, with bricks made by the dry press process holding an intermediate position.

Bricks made by each of these processes possess other properties than permeability that are desirable under certain conditions. The hand made repressed bricks, as an example, are less susceptible to rapid thermal changes than fire clay bricks made by the other processes. If the bricks are to be used in locations where they are not affected by rapid thermal changes, the gas permeability of the wall may be materially reduced by substituting fire clay bricks made by other processes.

Glazing or enamelling one or more surfaces of fire clay brick to render them impervious to gases is not practical from either a commercial or service standpoint. The cost of the glazing would be prohibitive in refractory bricks, and it would destroy other desirable and necessary properties. In addition, the glazing might crack or spall off under heat and lose its effectiveness in a comparatively short time.

Tests made of bricks of a hard, almost vitrified character similar to paving bricks, show that they are practically impervious to gas. Such bricks are very susceptible to thermal changes, and would not be satisfactory when used at a high heat or under sudden changes in temperature. However, bricks of this type can be used to great advantage as the outside covering for flues, regenerator chambers, etc., as they offer a greater protection against the leakage of gases than any other type of brick.

It has been proposed in some modern open-hearth furnace installations to have the flues, regenerator chambers, and other parts of the furnace covered with an air-tight steel shell to prevent the leakage of gas. Such a shell is costly, and it is very difficult to maintain it in an air-tight condition unless the shell be kept some distance away from the walls. It is necessary to have certain doors or openings in the shell and, after the steel becomes warped from continued use, it will be difficult to keep the openings sealed. In addition, it is not as accessible for repairs.

When cost and efficiency are both considered, the most practical method seems to be to cover the fire clay or other refractory bricks, wherever permissible, with an outside course of hard, almost vitrified bricks, using extra precautions to see that all cracks and joints between the bricks are well-filled with mortar. In addition, the walls should be coated with a mixture of sand, fire clay and sodium silicate to act as a further preventive.

Steel Prices

"I stand for large production and low prices, but not ruinous prices. The prices obtaining for steel products all too frequently are neither based upon investment and service nor justified by costs. Inadequate prices do not insure to the benefit of the public and in the long run are harmful alike to the employe and to the industry. Disastrous prices and ridiculous price instability benefit nobody. Order grabbing regardless, or a mad rush in slashing prices at the first indication, real or fancied, of softening in business is not salesmanship." — Eugene G. Grace, president, Bethlehem Steel Corporation.

The Operation of Large Hearth Furnaces Using Coke Made from One Hundred Per Cent High Volatile Coal

(Continued from page 322)

This theory is a possible explanation for the present tendency to increase the inwall batter on larger furnaces, and in accordance with it the inwall batter on the last two furnaces rebuilt at Carrie was increased to 1 in. per foot and 1.03 in. per foot, respectively, as against .92 in. per foot on the first two rebuilt furnaces. The last two, however, show but little improvement over the others. It must be considered, however, that they are blown with higher winds, causing higher pressures, and it is likely that this has offset much of the advantage gained by the increase of inwall batter. The remedy of course would be to further increase the batter until free movement of the burden results, but as this change includes possible derangement to other features of operation it should be done in very gradual steps. It would appear to be a logical conclusion, however, that irregular furnace travel can be remedied by an increase of inwall batter, thus compensating for high winds, small coke, fine ores or other conditions tending toward irregular movement.

Conclusion

Analysis of the operation of the blast furnace is a very difficult task. The chemical and physical properties of the burden materials impose their difficult tendencies upon the furnace in many ways. The variations existant in these properties combine to produce marked swings in the operation, which often mask the results of changes to such an extent that conclusions drawn may be wholly wrong. These conditions are responsible for the wide difference of opinion sometimes held regarding the various phases of operation. Mr. J. E. Johnson, during his investigations concerning the properties of alumina in the slag, remarked that since so many operators regarded it as a base and equally as many regarded it as an acid, he was quite sure it was neutral, and later was able to give substantial evidence to prove his contention.

Another difficulty confronting the investigator is the human tendency in making comparisons to see only the worst in his own operation and the best in the other. My effort has been to eliminate such tendencies in every way, but I am not at all certain of having attained complete success.

Finally, the value of making comparative analyses on operations can well be considered equal to that of costs. The theories developed in explaining the detrimental effect of various factors upon the operations often become the basis for changes which result in minimizing to a great extent the difficulty experienced. It is hoped that this paper may in some manner prove of benefit to such developments.

Several Types of Electric Drives Compared*

Electricity Is Rapidly Replacing Other Methods of Generating Power and Thus Instituting Economics Together With Increased Production. Steel Mills Among Greatest Users

By R. H. ROGERS†

IT is the purpose of this paper to outline some of the broader and perhaps less obvious effects of electricity in industry. The immediate physical effects following the adoption of electric drive; such as reduction of power requirements, elimination of shafting and belts, and the attainment of greater flexibility in the application of power; have been repeatedly and copiously brought to the attention of all concerned. There are several deeper and more far-reaching conditions and effects to the credit of electricity that have not received such generous attention.

Between 65 per cent and 70 per cent of all the power used in American industries is electric and the growth of this type of power is far greater than the total growth of power in industry. It is significant that the newer plants of an old established industry are the most nearly 100 per cent electrified and that the newer industries, such as the automotive activities, are, and have been from the first, practically 100 per cent electrified.

Our industries, in 1927, will use approximately 50 billion kwh. of electric energy, two-thirds of which will be purchased from power companies and one-third generated in private industrial plants. We can neither foresee the time when all industrial power will be electric nor when all the electric power will be purchased from central station systems. Many industries are characterized by the presence of by-product heat or by-product fuel or by uses for process steam. These items, together with privately owned water power sites, will long continue the use of other than electric power as well as the operation of private electric plants.

There is a strong trend, in the presence of by-product heat, by by-product fuel or private water power, to convert to electricity as the medium for getting the power to the work to be done. The same is true where low pressure process steam is required, as it is a quite general practice to utilize the exhaust or to bleed low pressure steam from the turbine of a turbine generator, the electrical output of which is used to drive machinery.

Effect of Substitution of Electricity

Having thus outlined the place of electricity in modern industry, some of its broader effects may be noted.

The first effect is the retirement of industrial plants to large industrial centers. Early operations were established at water power sites or in parcels along a stream to utilize several small water powers. Certain classes of work using great amounts of power on products of low unit value were for long considered feasible only with direct water wheel drive. The advent of electric power has changed all that. The small water power sites have passed out of the industrial picture. They are now combined into fewer heads and are driving hydro-electric stations tied in with steam stations to form great stable systems. The various enterprises are now fewer and larger. They are located in advantageous centers and enjoy full power the year around. Many times it has happened that a half dozen or more industries along a stream have pooled their water power rights, rescued the power formerly lost between plants, organized a hydro-electric company, reclaim all the power required for their own use and market an equal amount of surplus power. The tie-in with other systems has given stable power and the old power limit to their expansion has been removed so that they are free to grow how and where they please without having to consider power from the old water-wheel shaft to their manufacturing processes.

My second consideration regards the change in conditions for the personnel of industry. The little bleak, monotonous mill town is passing, men and women find their employment in large towns and cities where they can live broader lives. Their churches, theaters, contact with people otherwise employed and the conveniences and facilities at hand make for contentment and a negligible labor turn over.

From another standpoint electric power has revolutionized processes and made possible great concentration of power under the control of few workers. A man having the power of 10,000 men under his hand must be inspired and uplifted by his commanding position as compared to one who labors only with the power of his own hands. The president of the American Federation of Labor has said that electric power with all that it entails is the greatest single factor in the shortening of working hours for American industrial employees.

A third angle from which we might view this general subject is that of the release of space and capital for application to production. Under the older systems a considerable portion of plant space was given to the production of power, either in a centralized power house or more often in a number of scattered boiler and engine rooms, or water wheel housings. Purchased power particularly has made it possible to utilize practically every foot of plant for production, to say nothing of the bettered conditions for production which have been thoroughly covered in numerous publications.

Capital investments, overhead, and operation costs, are heavy items chargeable to power plant equipments and worst of all they are usually administered by those whose prime interests are in the manufacture of some product other than power. Purchased power has therefore made available for direct application to production millions of dollars that would otherwise be tied up in the more or less inefficient production and distribution of power.

Conservation of our natural resources, our fourth effect, is not the least valuable of the functions of electricity. It has made available vast water powers with constant direct saving of coal and it has, by concentrating steam power production into gigantic stations, reduced the coal requirement per horsepower as much as four-fold. Furthermore, it has made available for power purposes much of that wealth of by-product heat and by-product fuel that has in past years entirely gone to waste.

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*A paper presented to the A.S.M.E. at Erie, Pa., June 3, 1927.

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For the fifth subdivision of the subject we may consider the high rate of production that now prevails through the agency of electric power.

Electricity Increases Production

The ways in which production has been speeded up are so numerous and divergent that we can only dwell upon a few of the outstanding instances. The manufacture of paper is a good example because electric drive has pushed up production rates in all branches of the industry. Water wheel driven pocket type grinders for making wood pulp have given way to motor-driven magazine type grinders utilizing motors of 2,800 hp. They are most economically arranged and ton for ton require only one-seventh the labor formerly needed and the work is carried out on one-tenth the ground space.

The paper machines were limited by mechanical drive to speeds of 500 or 600 ft. per minute and in widths to less than 200 in. With individual electric drive the common speeds are now 1,000 ft. per minute with 1,200 feet attained in some cases. Certain new machines are designed for an ultimate speed of 1,450 ft. per minute and widths are now up to 270 in. or for a trimmed sheet 22 ft. wide made at a speed of over 15 miles per hour. With all this speed, reliability has been bettered and sheets 700 miles between breaks have been produced, while maintenance costs of the drive have dropped to one-fourth the figures that held for the older drives.

Woodworking in all its details has been speeded up. This effect is felt from logging and yarding clear through to the manufacture of the finest of wood products. Huge head saws tear through giant logs at unbelievable speeds under the urge of the relentless electric motor. At the other end of the scene tiny motors driving sanders, molders, tenoners and the like run at speeds unattainable by mechanical arrangements of gears or belts. Some run as high as 30,000 revolutions a minute with consequent rapid feeds and savings of rehandlings for grain directions so that production is speeded up to keep pace with these electrical times.

An abrupt change of thought brings us to the effects of welding by electric arc in manufacturing. The adoption for production purposes of this process which only a short time ago was looked upon as a means for making repairs or as a "putting-on tool" has been so rapid and far reaching that the general public and even those more intimately connected with the metal world are as yet unaware of its scope.

Arc Welding

Arc welding for thousands of products does away with patterns, castings together with casting losses, much of machining and withal results in lighter, stronger and better construction. It reduces necessary stock of materials and parts, and greatly shortens the time from completion of design or receipt of order to the finished article. The electrical manufacturer has not been slow in taking liberal doses of his own medicine, particularly is this true of General Electric where the arc weld has made possible marked reductions in the space occupied, in the time required and in the developments and shop costs of many of our major products.

Electric heat, while old in theory, has only lately come into prominence as a feature in manufacturing. The growth of heating loads on central station systems is astounding and it is freely predicted that its possiblities equal those of electric power. Wherever it is used, the result is a speeding up of the process coupled with better and more uniform results and a reduction in maintenance costs.

The sixth and last phase to be considered here is that of production costs. Costs are naturally reduced if power is delivered more cheaply at the place where the useful work is done. With the exception of the aluminum and ice industries the cost of power runs from one-half to six cents per dollar's worth of product. A change of 25 per cent either way in power cost would therefore affect total costs but little. The summation of the less tangible advantages of electric drive is of far greater importance and that is what has brought electric drive into undisputed leadership. The saving on capital charges and the release of space to other uses wherever electric power supersedes the older methods, has been outlined in previous paragraphs. We will now review some of the other ways in which production costs are affected.

Mining calls for the use of the largest power shovels for stripping overburden. Electric power shovels, besides lowering the visible costs per cubic yard show remarkable superiority from the maintenance standpoint. The largest steam power shovels require approximately $25,000 per year for maintenance, whereas the corresponding electric shovels are maintained for $5,000 per year. Little of that expense goes into the electrical features. The principal differences are in the steam plant upkeep and general repairs and replacements. Electric shovel drive, while more forceful than steam, has the faculty of minimizing shocks and strains so that with greater yardage the wear and tear is wonderfully reduced.

Mine hoists are among the most interesting power applications and developments have been carried to a point where no other form of power could possibly meet present day duty cycles. The result is reduced cost of production because, in addition to lessening the cost per 10 ft. of hoisting duty, fewer shafts are required and less additional expense is incurred as mines are deepened or output is increased.

Oil well drilling and pumping illustrates well the importance of what at first appear to be secondary considerations. While the power costs per foot drilled or per gallon pumped are primarily considered probably more owners are influenced by the reduced costs attributable to greater continuity of service, lesser capital investment and the improved conditions as to fire and personal hazards.

Steel Mills Driven by Electricity

Steel mills are among the greatest users of electric power and the newer the mill the more nearly will it be 100 per cent electric. Lowered production costs are obtained through being able, with electric power, to do things in ways and at rates that would otherwise be impossible. Concentration into great units reduces the labor cost even more than it reduces the power cost.

The large new paper mills, entirely electrified, using gigantic units, have cut production costs so that smaller old style mills are hard pressed or have given over their water power sites to hydro-electric stations. These results are not so largely credited to cheaper power as to reduced labor, reduced maintenance and more perfect continuity of manufacturing operations.

Examples without end could be cited to show the less conspicuous ways in which electric power reduces production costs but enough have been given to indicate that the more obvious characteristics are often of minor importance.

A summary of the effects of electric drive compared with older methods as noted in this paper, will serve to bring out more clearly the salient points.

1—Location and plant-plan freed from the old limitations as to source of power and its distribution.

2—Improved living conditions and a general uplift in personnel.

3—Release of capital and space for direct manufacturing operations.

4—Conservation of coal and oil by utilizing water power and by using fuel more effectively.

5—The speeding up of production makes more output possible per unit of space and per man-hour of labor.

6—Reduction of production costs results from various combinations of all the above, together with marked reductions in the cost of the power that is actually delivered to the work to be done.

Blast-Furnace Gas Studies

Results of a series of blast-furnace gas studies, made by J. F. Barkley, fuel engineer, United States Bureau of Mines, Department of Commerce, at one of the largest plants in the country, are given in Technical Paper 401, recently issued. One main object of these studies was to discover what relation existed, under regular operating conditions, between the amount of gas produced and the pounds of coke used per ton of iron. Another object was to determine what were the variations from day to day between the amount of gas actually produced and the amount found by calculation from the furnace charges. Included in these studies was the plotting of the main items of observation in simple relationships, in order to bring out any consistencies of blast-furnace action in the production of gas. Technical Paper 401 may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 5 cents.

The Largest Riveter

In our May issue we stated that the largest hydraulic riveter ever built in this country had been completed and shipped by the Chambersburg Engineering Company of Chambersburg, Pa. We have since learned that this was an error, as the largest riveter so far built in this country was a forged steel stake riveter with 20 ft. 6 in. gap, manufactured by R. D. Wood & Company of Philadelphia, for Walsh & Weidner Boiler Company of Chattanooga.

Endurance of Metals Under Repeated Stress

Among the large research enterprises in fatigue of metals has been the one at University of Illinois under the auspices of National Research Council and Engineering Foundation with the co-operation of important industries. Professor H. F. Moore has been in charge. To meet a demand for information in form usable by designing, inspecting, testing and operating engineers, Engineering Foundation asked Professor Moore to compile a small manual and invited other leading American investigators to co-operate. The product is the "Manual of Endurance of Metals Under Repeated Stress," presented the knowledge gotten by researches occupying several years of work by a score or more of investigators and many advisors, and costing in the aggregate a few hundred thousand dollars.

This book is offered at the price of $1. Orders and remittances should be sent to Engineering Foundation, at 29 West Thirty-ninth Street, New York.

Continuous Sheet Mill at Ashland

(Continued from page 338)

laboratory for the testing and inspection of the sheets as they are finished. In this laboratory every lot of 15,000 lb. of sheets is thoroughly tested by being passed through Rockwell, Olsen and Erichsen testing machines. Pieces are also subjected to microscopic examination and sheets to a rigid surface inspection.

The warehouse and buildings in which the finished sheets are handled are of the most modern design; furthermore, in them the equipment is of the latest pattern for the efficient and expeditious movement of material.

Quality of Sheets

The sheets, shipped from this plant, must be of the highest quality as they are used in the construction of automobile bodies and for other purposes where inferior grades would not meet the specifications. Pure iron sheets of the well known "Armco" brand for rust resisting and enameling purposes, as well as special steel sheets for the automotive trade requiring particular composition, heat treatment, and surface finish, are all made by this process.

Conclusion

In the foregoing description the equipment and the manner of operating it, is outlined in some detail, but an adequate presentation of the subject as a whole would involve a recital of the many obstacles which have been overcome, and the perfecting of features, which are not apparent in the finished machine. Inasmuch as the construction of this mill was started in 1922 it is obvious that much labor and money have been expended in creating a continuous mill which would produce sheets in sufficient quantity and of the requisite quality to make it an economic success. That this goal has been achieved is indeed a tribute to the organization which sponsored the venture and to the ingenuity of its engineers.

The process involved in the rolling of the sheets, as well as numerous developments of equipment, is covered by patents assigned to The American Rolling Mill Company.

Soaking Pit with Recuperator

Recuperation Applied to "Pits" in European Plants With Satisfactory Results. Installation in American Mill Increases Efficiency. Advantages Pointed Out

UNTIL recently very little change has been made in the general characteristics of soaking pit design. Since the original regenerative principle was employed, improvements have been made from time to time, but have had to do chiefly with the grade of refractory employed and the type of reversing equipment used.

In its original conception, the soaking pit consisted merely of an underground pit, in which the ingots were placed as soon as possible after casting in order that they might equalize their temperature before rolling. No attempt was made to supply additional heat to this pit until many years later. Soaking pits at this time were not employed for heating cold ingots, and production was such that ingots were used as made.

Additional heat over that contained in the hot ingot had to be supplied to the pit in order that the ingots could be held at the proper rolling temperature until wanted. This was also necessary in order that cold ingots might be heated. Regenerative checker chambers were next added to the soaking pit for the purpose of salvaging heat from the waste gases and preheating the air and gas before entering the combustion chamber. The added regenerators made it necessary to reverse the flow of gases periodically, since the heat in the waste gas was stored up in the brick checkers and was only transferred to the incoming air and gas after the flow of gases was reversed. In addition to the fuel saving, a faster heating pit was obtained, due to the increased flame temperature resulting from the preheated air and gas. In spite of the big advance made by the addition of regenerators to the soaking pit, it has long been known that the thermal efficiency of the soaking pit as a transfer unit is extremely low. The figures from a recent heat balance obtained in an extremely modern installation give a thermal efficiency of only 8.6 per cent.

Due to the design of the regenerative soaking pit, the exhaust port and firing port are on opposite ends of the pit, and the flame travels through the pit without change of direction. Since the ports are of necessity considerably less in height than the ingots being heated, the port velocity alone tends to give concentrated firing and "channeling" of the gases throughout the length of the pit to the exhaust port, which results in unequal heating of the ingots, and necessitates a long, fuel-wasting, soaking or equalizing period.

Regenerator Faults

Most regenerative installations are built without sufficient depth of checkers. This lack of depth, coupled with the friction losses through the air valve and flues connecting air valve to regenerator, very often results in a tendency toward a lack of air being available at the firing port. Such a condition causes the pit to be operated with a minus pressure in the combustion chamber which is only obtained by a high stack draft used in an effort to induce the air into the pit by reducing the pressures therein. A pit operated under minus pressure results in unevenly heated steel, for the flame traverses the shortest possible path and "channels" between the firing port and exhaust port.

Uneven heating of the ingots causes the operator to use an extremely reducing flame during most of the firing period in order that the heat may travel through the ingot from top to bottom and thus equalize the temperature. In regulating the pit to obtain the reducing condition, the operator cuts down the air, uses a big excess of gas and obtains a lower flame temperature. This gas frequently burns in the checkers or passes out the stack unconsumed and causes a big fuel loss and a correspondingly low efficiency for the pit.

Due to the short time interval the gases have between leaving the firing port and entering the opposite checker chamber, it is found very frequently that the highest temperature is reached in the checkers, causing high maintenance for checkers and ports, with further heat losses due to the combustion occurring in the wrong place.

In France, fuel economy has always been of major importance and was the primary reason for the application of the recuperative principle to soaking pits. Recuperative soaking pits have been in operation in France for many years and have proven conclusively the increased efficiency which can be obtained with this type pit. However, the French type recuperative pits are much smaller than American practice would consider desirable—usually holding two ingots per pit.

American Installation

Results derived from the recuperative type pit in France looked so beneficial that considerable time was spent in adapting the recuperative design to American practice, resulting finally in the construction of a trial recuperative pit at the plant of the Donner Steel Company, Buffalo, N. Y. This pit is 5 ft. 6 in. in width, by 9 ft. 6 in. in length, holds 6 ingots 21½ in. square, of approximately 7,800 lbs. each, and has been in operation since February 7, 1927, giving excellent results and fully justifying the many claims made for its operation.

In designing the original recuperative pit, care was taken that the recuperator be sufficiently large and placed low enough to provide all the air necessary at the firing port at all times and deliver it at a pressure great enough to maintain a positive pressure condition in the combustion chamber. This made the heating condition in the combustion chamber much better than to be dependent on the stack pull to supply air, which would of necessity mean a minus pressure in the heating chamber, such as is often found in regenerative pits. A slag pocket was also located between the pit and recuperator to eliminate the troubles which frequently occur in regenerative pits when cinder runs through the bridgewall into the checker chamber.

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Since the firing and exhaust ports are located in the same end wall, a complete circulation of the gases through the combustion chamber is assured. An additional benefit is obtained by having the firing port above the top of the ingots, which effectively prevents the gases from coming in contact with the steel as soon as they enter the combustion chamber, thus insuring complete mixing and thorough combustion.

Advantages with Recuperators

In addition to overcoming the well known regenerative pit troubles already mentioned, there are many additional advantages which are to be obtained by the use of a recuperative soaking pit. These are listed as follows:

1—*Reduced floor space required.* Less floor space is used, due to the fact that the recuperator is located at one end of the pit rather than at both ends as is the case with regenerators. This is shown in Fig. 1. A new soaking pit building would be much smaller than that required for the same number of regenerative pits.

2—*More capacity in existing pit buildings.* By rearranging the soaking pits, it is found that recuperative pits can be installed in existing pit buildings to give from 50 to 100 per cent increased ingot capacity. This is due to the less floor space needed, and the ease with which the size of the pit can be increased to take a greater number of ingots. It is usually found that 12 holes can be installed in the space required for eight regenerative holes and that, if desired, these 12 holes can be built for eight ingots each rather than six as most commonly used for the regenerative pit.

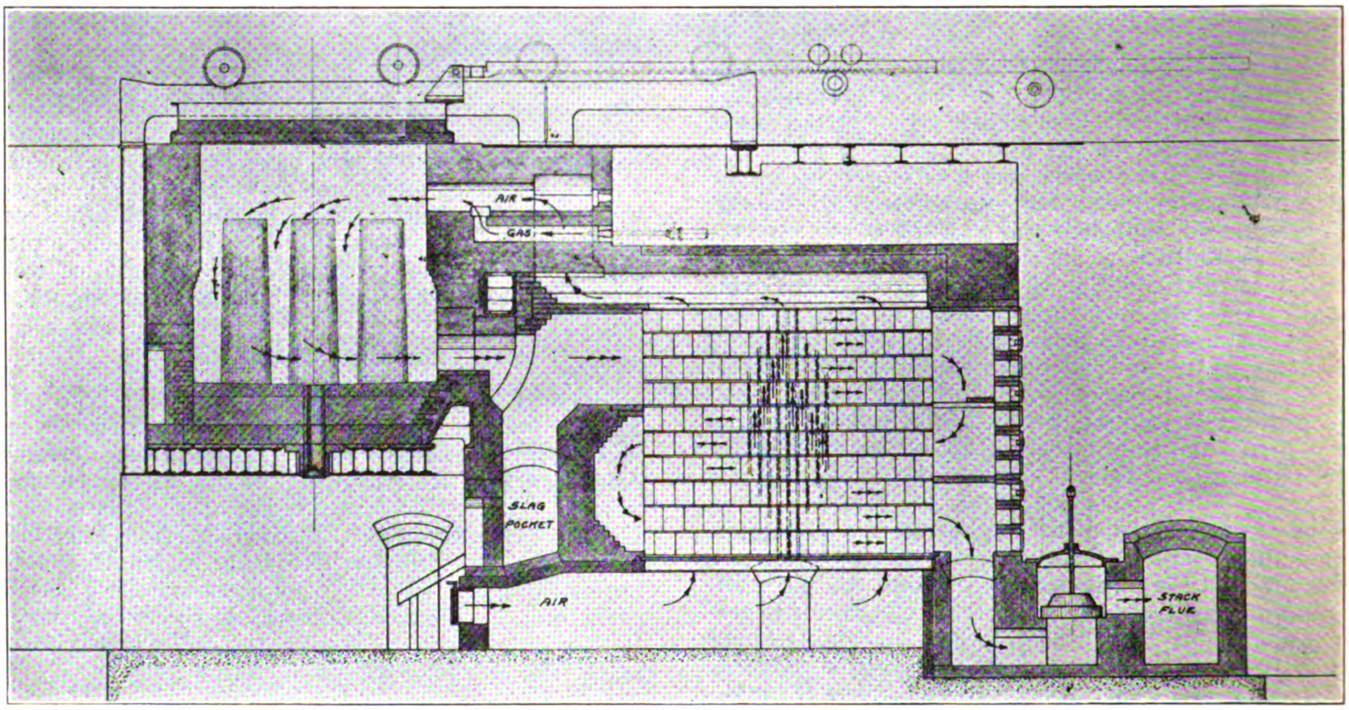

FIG. 1—Cross-section of soaking pit and recuperator.

3—*Less first cost.* The cost of such an installation is readily seen to be less than the regenerative type, when buildings, reversing valves and crane are taken into consideration.

4—*No reversing valves.* The recuperative principle of firing eliminates the use of reversing valves, since the flame is constant in its directional flow. As shown on Fig. 1, the firing port is located above the outlet port, and the flame is directionally constant in this vertical horseshoe travel. Since a recuperator permits the passage of the air being preheated and the waste gas being cooled to flow through the same chamber, reversing is unnecessary and the reversing valves with their maintenance are eliminated.

5—*Ease of operation.* In the regenerative pit, the checker chambers are alternately being heated up and cooled down—the amount being determined by the period between reversals. It frequently happens that the checkers on opposite ends of the pit become unbalanced as regards temperature, due to different periods between reversals and also due to the different amounts of friction through the flues leading to and from the checker chambers. This unbalanced condition causes the operator to give very close attention to the unbalanced pit if the material is to be properly heated since every time the flow of gases is reversed, air, gas and stack valves must be reset to suit the new conditions.

The recuperative pit removes any possibility of uneveness in heating conditions by eliminating reversals. Since the temperature of the air is preheated by the outgoing waste gases the whole unit becomes correlated and the recuperator acts similar to the flywheel on an engine, eliminating any sudden variations in temperature or flame conditions, all changes being gradual and under the operator's entire control at all times.

6—*Less radiation losses.* With regenerators at each end of a single pit, eight walls are in contact with the outside air losing heat by radiation. The single recuperative pit has but one wall which can do likewise—that, the plug wall end of the recuperator with its observation holes. Fig. 2 shows the recuperator construction, and it will be noticed that the sidewalls are in contact with the tile through which air is passing and these tile and the air effectively prevent the radiation of heat from the waste gases through the sidewall. The end opposite the plug wall, (see Fig. 1), is separated from the outside air by the slag pocket, effectively preventing any waste gas from being in contact with this outside wall, and thereby cutting down radiation to approximately one-eighth of that found in a regenerative pit.

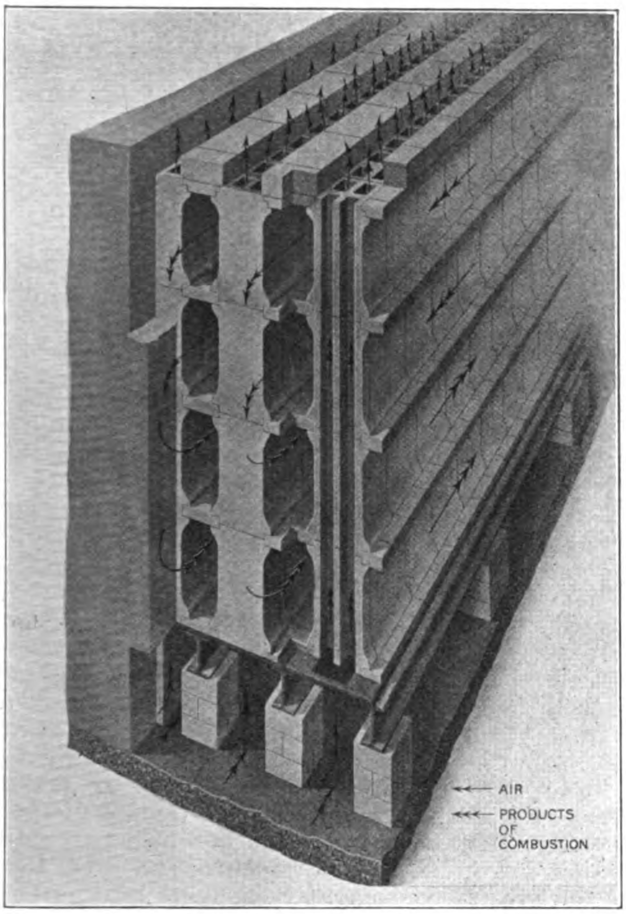

FIG. 2—Construction of recuperator. Arrows indicate flow of gas and air.

7—*Efficiency and fuel consumption.* The decreased fuel consumption obtained with the recuperative type pit is due to a number of factors. Decreased radiation, as mentioned above, is one. Another is the fact that the ingots are heated uniformly throughout their length from top to bottom due to double flame travel. This uniform heating eliminates the fuel wasted when the operator finds it necessary to reduce the pit temperature with excess gas while the heat equalizes itself throughout unevenly heated ingots. Since the flame travels the length of the pit twice, it is in the recuperative pit more than double the time that it is in the regenerative pit. This results in more complete combustion and the consequent liberation of more heat in the pit proper. It also eliminates high flame temperature in the checkers so often found with regenerators. This point saves much fuel. The stack temperature of the gases leaving the recuperative pit—fired with coke oven gas—average below 800 deg. F. with an analysis of stack gases having below 1 per cent. Corresponding regenerative temperatures average 1,300 to 1,400 deg., with as high as 5 per cent oxygen present. This is partially due to the greater efficiency of the complete recuperative unit over the regenerative and also partially due to the elimination of air infiltration which always occurs through the sidewalls of regenerators.

8 *and* 9—*Complete circulation of gases and uniform heating.* Uniform heating is due to the complete circulation of the gases throughout the entire hole; more complete combustion results from the change of direction.

10—*Positive pressure.* Since the recuperative pit does not use reversing valves the friction losses met with by the air in passing through the valves and air flues to the regenerator are eliminated. Since the recuperator does not have to work against the added friction it delivers the air to the firing port under a positive pressure, thereby keeping the pit full of flame at all times. This eliminates both "channeling" through the pit and infiltration of air into the pit around the cover. It also cuts down oxidation losses and helps to heat the ingots uniformly.

11 *and* 12—*Less Maintenance and longer life.* The maintenance on the combustion chamber is approximately the same as with any regenerative pit—it being well known that the type of refractory used and the method of charging and discharging are the determining factors entering into the life of the combustion chamber proper.

Maintenance of the recuperator in comparison to regenerators is much reduced, due to the fact that the recuperator tile never get the severe treatment which the checkers must undergo in the regenerative pit. Each tile is in fact an air-cooled refractory, since it preheats the air passing through it at the same time it is being heated by the waste gases. As a result, the recuperator tile are never heated to the extreme temperatures that checker brick are subjected to and, as a result, have a life indefinitely long.

Regenerative pits have high maintenance of checker chambers, due to the slag often cutting through the bridgewall and entering the checkers. This is made impossible in a recuperative pit by the slag pit provided between bridgewall and recuperator. Although the slag pit is provided it will not be used frequently due to the much longer life of the bridgewall in the recuperative pit, since it is not subjected to the high flame temperature conditions found in a regenerative pit—where combustion frequently occurs as the gases leave the pit proper. The firing port likewise has extremely low maintenance, since it is used only as a firing port in which the temperature encountered are much lower than those in a regenerative pit where reversing occurs. If combustion occurs where it should, namely, in the pit proper, the temperature of the waste gases leaving the pit will be considerably lower than as though combustion does not occur until the gases leave the pit with maximum temperature at this point. This condition is often found in regenerative pits.

Less maintenance is also assured due to the elimination of reversing valves and their operating equipment.

13 *and* 14—*Slag hole at the end of pit.* A regenerative pit by necessity has the cinder hole at the bottom making it somewhat inaccessible from beneath and extremely hard to work from above. With the recuperative pit one end wall is available for the installation of a cleaning door which is located at the hearth level and makes easier cleaning and bottom

(Continued on page 355)

The POWER PLANT

Waste Heat Boiler Applications*

Reclamation of Waste Heat Presents Extensive Field for Obtaining Worthwhile Economics. Effect of Radiant-Heat Negligible—Results with Five Tube Boilers Recorded

By A. J. EBNER†

IF a history of industrial progress were to be written, it would be shown that the outstanding incentive behind all new development is the elimination of waste. Whatever the nature of the saving may be, in material, human effort or time, it is intimately a part of economic advancement. In fact the extent of such saving can very well be the measure of our industrial welfare.

Upon the class of industrial service rendered, depends the nature and importance of the savings to be sought. The cost of fuel no doubt plays a part in manufacturing enterprises second to no other item in general importance. And yet, we find that while many large central power stations stand out prominently as leaders in the economical use of fuel, there is much to be done for the isolated power plants and still more for industries using fuel for other purposes than the generation of power.

The rejection of heat to the atmosphere in waste gases has created a fertile field for fuel-saving devices and calls to mind the age-long use of recuperators and regenerative equipment in metallurgical furnaces, and later the economizer and air preheater in steam boiler practice, as well as heat exchangers, dryers and evaporators in specialized processes. The extent to which such measures for heat recovery are economically sound is in inverse ratio to the thermal efficiency of the operation forming the source of heat.

Boilers on Puddling Furnaces

Naturally the worst offenders in respect to fuel economy were the first to receive treatment for the recovery of dissipated heat. The earliest types of waste heat boilers were applied to puddling, heating, and other non-regenerative furnaces in which as much as 80 per cent of the heat in the fuel leaves the furnace in waste gases of combustion. These boilers were at first simply cylindrical shells without flues or tubes, and were usually mounted directly above the furnace. Development of the idea led to the adoption of water-tube boilers for this type of furnace with very good results, due to the high temperature of the escaping gases.

The application of boilers to regenerative furnaces was retarded on account of the relatively low gas temperatures, it being considered inadvisable at one time to generate steam commercially with gases below 1600 deg. F. Moreover, with the high draft intensity already made necessary by the regenerators, it was feared that furnace operation would be impaired by a further piece of equipment requiring still more draft while at the same time reducing the available draft by lowering stack temperatures. It should be noted here that the early installations of waste heat boilers depended upon natural draft for movement of the gases.

Open-Hearth Furnace Equipped

It was in 1910 that the first installation of a waste-heat boiler was made on an open-hearth furnace. The boiler was a conventional type of water-tube design, equipped with induced draft fan to overcome the loss of draft resulting from lower stack temperature and friction through the boiler and flue connections. The operation of furnace and boiler is principally of interest in that it proved the application feasible, without in any way impairing the production or quality of steel. Further development led to the use of specially designed water tube boilers in which particular attention was given to gas velocities and draft loss, until the greatest capacity per sq. ft. of heating surface was obtained with a given draft resistance.

Experience with water tube boilers showed that the principles governing designs for direct fired service do not fully cover the needs of effective waste heat recovery. Radiant heat is a factor of little importance in a boiler utilizing waste gases, whereas heat transfer by convection and conduction plays a major part. Consequently, the heating surface must be in close contact with the gases, which should move at velocities great enough to break up definite stream lines, and thus prevent the formation of a cool gas film next to the surface of the tubes. This is particularly true in the case of gas flow parallel to the tubes, since with gas travel across the tubes more or less turbulence is set up by impact. In the latter case, however, the heating surface, effectively swept by the gases, is considerably reduced, inasmuch as a portion of each tube on the side away from the direction of flow is not in active contact with the gas. This inactive area of each tube is prone to gather dust which still further reduces the transfer of heat. With either parallel or cross flow it is necessary to move the gases at a higher velocity than is usually possible with natural draft, the former requiring speed for turbulence, and the latter to overcome inertia losses, due to repeated impact and acceleration.

A common difficulty in the operation of water-tube waste-heat boilers is caused by air infiltration

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*Combustion, June 1927.

†Freyn Engineering Company.

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through the brick settings, due to the high draft intensity usually required. The effect is to dilute the products of combustion, reducing their temperature and at the same time adding to the weight of gas, which the induced draft fan must handle at the expense of additional power. Attempts at maintaining the settings tight by pointing the brickwork and applying boiler wall coatings have not been particularly successful. The difficulty has been met by incasing the entire setting with an air-tight steel casing. Dust accumulation and removal are still problems with the water tube type, although much can be done through the frequent use of portable and permanent soot blowers.

Merits of Fire Tube Boiler

Consideration of all the factors relating to efficient production of steam by waste heat brought out the merits of the fire tube boiler for this class of service. This type is well adapted to provide the essentials of high rate of heat transfer by convection, and low draft loss. The term "mass velocity" is frequently used in waste heat calculations to indicate the weight of gas flowing per unit of gas passage area. For a given mass velocity and with tubes of equal size, the water tube boiler will give a higher rate of heat transfer than the fire tube, but at the expense of higher friction. Now, by increasing the mass velocity in the fire tube boiler to a point where the frictional resistance will equal that of the water-tube boiler, the former takes precedence in the rate of heat transfer by convection. The reason for this is that no practical arrangement of water tube spacing and baffling can be devised to hold the gases in close contact with the heating surface, as is possible in the fire-tube design with equal draft loss. The requirements for ideal gas travel are found in a straight circular passage, the inside of a tube, by which means there is eliminated the loss due to irregular channels, changes in direction of flow, short-circuiting of gas through baffles, and ineffective heating surface by reason of dead pockets in the gas passages. Heat tranfer is augmented by reducing the size of tubes in order to confine the gases closer to the heating surface.

The net result of a comparison of both types, basing conclusions only on heat transfer rates, is that the fire-tube boiler will operate at a higher rating than the water-tube under similar conditions of service. In addition to this the fire-tube boiler is proof against air infiltration since it requires no brick setting, and further its heating surface is easily kept free of dust accumulation. On the other hand the water-tube boiler has an advantage in its accessibility for the removal of scale, the importance of which, however, is lost with the use of treated feed water.

The fire-tube waste-heat boiler went through its cycle of development with creditable performance from the beginning, and improvement aside from details of construction has been in regard to gas velocities. The preferred form of boiler is a horizontal single shell, containing tubes of small diameter and relatively great length. The tubes and front tube sheet are the only parts of the boiler making contact with the hot gases, the construction being similar to the locomotive type of boiler forming a single pass for the gases to travel. The shell rests on two floor saddles, in which provision is made for movement due to expansion. Inasmuch as the shell is not used as heating surface, brick settings are dispensed with and it is only necessary to cover the exposed surface with magnesia or similar insulating material.

A waste heat boiler unit generally comprises the boiler, superheater, induced draft fan, and flue and stack connections with dampers and valves for putting the boiler in and out of service. The superheater is placed in the hot gas duct immediately preceding the boiler. The gases after sweeping the superheater enter the boiler, from which they are drawn through a short steel breeching, connecting to the fan. The latter is of the steel plate type, direct-connected to an adjustable speed motor, or through speed reduction gears to a steam turbine. Furnace draft is thus under complete control of the operator, who can secure a wide range of draft intensity through regulation of the fan speed.

Fire Tube in Practice

In open hearth steel practice the fire-tube waste-heat boiler recovers about 30 per cent of the heat supplied to the furnace, or from 1,900,000 to 2,500,000 Btu. per ton of ingots. This heat is available in the form of steam, which, if generated in coal-fired boilers at 70 per cent efficiency and with 1,000 Btu. coal, represents an average saving of 285 lbs. coal per ton of ingots.

A typical installation of fire-tube boilers was made in 1925 in two 30-ton open-hearth furnaces, using a cold pig and scrap charge and burning fuel oil. The design was based on the normal furnace operation of which the following data was available:

Metallic charge	68,000 lbs. cold pig and scrap
Fuel consumption	1,170 gals. oil per heat
Weight of oil	7.97 lbs. per gal. 18,800 Btu. per lb.
Time of heats—tap to tap	7 hours
Temperature of waste gases at base of stack	1,350 deg. F.
CO_2 in waste gases at base of stack	8.75 per cent by vol.
Draft required at base of stack	1.25 in. W. G.

The general arrangement comprised a boiler to each furnace, with its complementary equipment of superheater, motor-driven induced-draft fan, and underground flues from furnace to boiler and boiler to furnace stack. It was possible to place the boilers and fans under the furnace charging floor, thus saving the expense of a separate house. The location made it necessary to carry the steam a distance of 700 ft. to connect with the steam header of the existing power plant. Treated feed water was brought the same distance from an open heater serving the direct fired boiler house. Each boiler was designed to handle a normal gas flow averaging 40,000 lbs. per hour, with a draft loss of 2½ in. through boiler and superheater. A test of one of these units is tabulated below, the three columns of figures being divisions of a continuous 24-hour run, each column covering one of the three open-hearth heats taken out in the 24-hour period.

In the above case each boiler contains 2,350 sq. ft. of heating surface. The rate of heat transfer is thus 9.15 Btu. per sq. ft. per deg. mean temperature difference per hour. The gross recovery of heat in the form of steam represents 39.2 per cent of the heat input to the furnace, which after deducting 2.8 per cent of the boiler output used in driving the fan leaves a net recovery of 38 per cent.

The cost of the complete installation inclusive of equipment, foundations, flues and dampers, insulation,

(Continued on page 355)

Developments in Steam Pressures*

A Comprehensive Survey of the Generation and Utilization of Power from the Boiler to the Turbine. Accessory Equipment Today Plays an Important Part in Increasing Heat Economy

By W. BAYLISS†

TODAY'S economic conditions are imposing upon us the necessity for efficiency in every phase of industrial activity, and not the least important is the economical generation of power, for in many industries cheap power is the governing factor in the producing of low manufacturing costs.

The production of cheap power is in no small measure dependent upon the efficient utilization of the materials of construction.

The purpose of this paper is to outline modern developments in the generation of steam at higher pressures than normally obtain at the present time, and to touch generally upon the auxiliary devices outside the actual steam generator which combine to attain the high over-all efficiencies of present-day boiler plants.

Increased efficiency, both in land and ship installations, with the consequent economy in fuel as well as the desire to make steam installations give the same calorific efficiency that is obtainable from the "Diesel" engine, is the origin of many improvements that have appeared in steam plant.

These improvements are based mainly upon the increases of pressure, feed temperature, temperature of steam superheat, and air heating, and in the case of superheat are restricted to the limit of temperature which the materials available for use will withstand.

You are aware that the scientific foundation and advantages associated with increased temperature and pressure have been known since the days of Carnot (100 years ago), Rankine and others.

Many years ago Perkins built marine machinery to work at a steam pressure of 1,500 lbs. per sq. in., but his efforts failed owing to the lack of mechanical facilities, and of the knowledge and machinery required for the construction of suitable boilers and engines.

The gain due to the use of the higher range of steam pressure arises partly from the fact that the heat content per pound of steam increases only slightly up to 350 lbs. per sq. in. gauge pressure, and according to Stodola it commences then to diminish slowly as the pressure is increased above 350 lbs.—no more heat, but theoretically slightly less, has to be transferred from the fuel to the water at the increased pressure.

The total heat contents of steam at the higher pressures as given by Stodola are at slight variance with figures put forward by other authorities, but we may with reasonable correctness state that the total heat contents of saturated steam between pressures of 200 lbs. per sq. in. absolute and 1,100 lbs. per sq. in. absolute does not increase more than about 2 per cent—this latter figure being the maximum increase as shown by other experts.

It should be observed that the efficiency of boilers is not materially modified, but changes in design and construction have been made to enable higher pressures to be used, with which per unit of steam more work can be done by the power machine. It is only in recent years that the construction of steam generators suitable for the higher pressures has been studied and become practicable, and the results obtained have been entirely from land practice.

Application of High Pressures

The development of the application of high pressures has taken place in the following directions:

1—In specially constructing turbines to utilize high-pressure steam, 350 to 650 lbs. per sq. in. throughout the whole range, by increasing the stages of expansion in one machine, and either reheating or operating with the initial steam at very high superheat temperatures.

2—In utilizing pressures 600 to 1,200 lbs. per sq. in. for new turbines which exhaust at pressures of from 200 to 350 lbs. per sq. in., and using this exhaust steam in existing plants.

Of the former we have examples:

	Working Press. Gauge	Temp. Deg. F.
Manchester Barton Power Station........	375	750
North Tees Power Station..............	475	700
County of London Electric Supply Company (New Barking Power Station)....	375	730
Philo Station of the Ohio Power Company	575	750
Crawford Power Station of the Commonwealth Edison Company..............	575	750

In the second category we have examples:

Bradford Corporation	1100	800
Weymouth Station, Boston, Mass.	1200	700
Langerbrugge Power Station, Ghent......	800	840

Recently a Clyde steamer has been put into service with high-pressure boilers, operating at 575 lbs. per sq. in., 750 deg. F. steam temperature, and the results being obtained are attracting great interest, and later in the paper a stated result will be given.

In the manufacture of the higher pressure boilers the greatest care is required in the design of all the fittings, for on these the success of high pressures largely depends. Safety valves and water gauges probably require the most consideration.

In the manufacture workmanship and accuracy equalling the highest engineering practice are requisite, and for a pressure below, say, 500 lbs. per sq. in. when riveted steam and water drums are embodied the drum ends are accurately turned to insure a driving fit into a bored shell. Riveted holes are specially formed through the very thick plates with practically a reamer finish. Rivets must be truly cylindrical in the body with the minimum of clearance between rivet and hole before the closing of the rivet head. The rivet must be entirely cleaned of all scale before use. All tubes at their expanded ends are buffed to a polished surface and entered into perfectly clean holes so as to insure a metal-to-metal joint in the expanding process.

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*Paper read before the Manchester Association of Engineers.

†M. I. mechanical engineer.

All tubes are bored to limit gauges, and special expanders are necessary for expanding the thick tubes into their seats, as also for bell-mouthing. All tubes are of solid drawn steel and pass a very severe test before being passed out from the tube mill for use in the boilers.

At the Langerbrugge station, Ghent, Belgium, a riveted drum construction was adopted for a pressure of 800 lbs. per sq. in., and has proved in every way satisfactory, but the expense of manufacture has suggested the use of weldless drums for steam pressures of probably 500 lbs. per sq. in. and over.

Welded Drums

Welded drums have been suggested, but it would appear a rather risky procedure to entrust a weld in tension to the high stresses due to pressure and temperature, having in mind the serious consequences which would follow a rupture.

With the high superheat steam temperature now being adopted, the position of the superheater relative to the boilr heating surface has been modified.

For temperatures of 700 deg. F. and upwards the superheater is arranged nearer the furnace combustion chamber. In this position the desired steam temperature can be secured with an economy in superheater heating surface; further, variations in the boiler evaporation do not result in wide differences in superheat temperature.

Earlier in the paper a case was cited at Langerbrugge of a steam temperature of 840 deg. F. The author inspected these superheaters after 12 months' service, but no evidence of deformation of tubes or material was apparent, although over short periods during the initial starting up of the plant steam temperatures as high as 1,000 deg. F. were recorded. At the same time working temperatures above 750 deg. F. are so exceptional that it is unwise with the materials available to speak too confidently.

Reference has lately been made of special steels of Swedish manufacture which are reputed to be reliable, and maintain their strength up to 1,400 deg. F., but whether such steels are suitable for tube making and working into the requisite shapes is not stated.

The feed-water economizer is retained in the majority of installations, but to a much less degree. In consequence of feed-water heating by steam bled from the intermediate stages of steam turbines, feed temperatures are now offered to the boilermaker ranging to 350 deg. F. At such temperatures the economizer plays either no part or only a small part, dependent on the particular boiler pressure with its consequent saturation temperature. It is obvious that there must be a fairly large gap of temperature between the feed-water temperature to the economizer and the saturation steam temperature corresponding to boiler pressure.

Economizers

The higher pressures have brought into service economizers built up entirely of solid drawn steel boxes and tubes; the tubes are of small bore with high water velocities above the critical velocity of turbulence at all temperatures and normal rates of working, and are arranged to permit of the counter-current flow principle to be adopted. Economizers so designed have proved reliable; in consequence dampers for by-passing gases past the economizers are now eliminated, thereby removing any possibility of losses due to damper leakage.

Having been offered from the turbine makers temperatures of feed water of, say, 250 deg. F. to 350 deg. F., ways and means had to be found to reduce the temperature of exit gases before reaching the atmosphere, and recourse has been made to the air heater.

Air heaters vary greatly in design from the simple tube air heater, the built-up plate heater, to the revolving plate heater, each type having its own advocates. The limit to the temperature of air delivered to the boiler furnaces is to a great extent governed by the behavior of the refractory materials available for lining the boiler furnace and combustion chambers; the higher the air temperature the higher becomes the combustion chamber temperature. The introduction of water-cooled furnace walls is enabling higher air temperatures to be adopted.

At the present time air temperatures to furnaces above 350 deg. F. are the exception, although some experience is available up to 450 deg. F., but experience at the present time rather tends to temperatures not exceeding 350 deg. F.

Air Heaters

The gain in the efficiency due to the use of air heaters may be greater than that corresponding to the heat absorbed by the air heaters, on account of the heated air increasing the heat absorbed by the boiler and improving the efficiency by combustion.

In certain cases air heaters have the added advantage of increasing the available boiler capacity by making it possible to burn a greater amount of coal, as also enabling a lower grade fuel to be used.

We come now to what at the present time is a vexed question—viz., stoker firing or pulverized fuel firing,—and the author does not intend within the scope of this paper to debate the subject.

Mechanical stokers have in late years improved considerably in design and performances, and can efficiently deal with coals of say, 8,000 Btu. and upwards.

The advent of the balanced draught stoker operating with heated air has enabled low-grade fuels (which a few years ago could not be utilized) being efficiently dealt with. During the recent coal dispute a case is on record of coal, or perhaps I should say fuel, of about 6,500 Btu. being dealt with successfully.

Further, the capital cost and power required for operation are low. One bhp. will drive a stoker of, say, 200 sq. ft. grate area.

Pulverized Coal

Regarding pulverized fuel, there is no doubt a very useful field for this equipment, particularly for dealing with very small coal, slurry coals, and washery dant. The handling of the two latter quality material between the transport vehicle and to and from the bunkers is a difficult and complex problem, and the drying of this class of fuel, which is liable to contain up to 30 per cent of free moisture, necessitates a large and costly equipment before pulverizing is possible.

The efficiency data available are mostly provided by American installations which operate usually with coal of high calorific value and low moisture contents, which are not wholly applicable to the fuel which we in England desire to use. There are no figures available, as far as the author is aware, from plants in England showing an advance upon authentic net efficiencies obtainable from our up-to-date stoker-fired equipments. This fact does not, of course, condemn the principle.

Until additional reliable data are available it would appear that fuel which can be efficiently burnt on stokers still represents the cheapest method of dealing with such fuel when efficiency is represented by actual net cost of steam generation.

A useful and efficient apparatus has of recent years been introduced into England from America—viz., the steam soot blower, the use of which enables a clean heating surface to be maintained, with consequent maintained efficiency. With this apparatus in use the gas exit temperature can be maintained over periods of a boiler full-load service within 10 deg. F.

Furnace Design

Furnace design has during the last few years been more carefully studied. The rating of boilers per sq. ft. of heating surface having been greatly increased, furnace volume or capacity to satisfy correctly the burning of a greater quantity of coal has been increased.

You will no doubt be interested in a few examples of extra high-pressure steam generators, showing the auxiliary plants described earlier in the paper:

The Langerbrugge Power Station Boiler

Steam pressure	800 lb. per sq. in.
Steam temperature	842 deg. F.
Temperature rise in air heaters	360 deg. F.
Normal evaporation per hour	26,400 lb.
Feed temperature to boilers	384 deg. F.

No feed-water economizers are installed.

The Weymouth, Boston, Boiler

Steam pressure	1200 lb. per sq. in.
Steam temperature	700 deg. F.
Exhaust steam at 360 lb. per sq. in. passed through reheater and raised to	700 deg. F.
Normal evaporation	143,000 lb. per hour

The drum is of seamless forged steel 48 in. internal diameter and 4 in. thick.
An economizer is installed, but no air heater.

Amsterdam Power Station, Holland

Steam pressure	620 lb. per sq. in.
Steam temperature	710 deg. F.
Normal evaporation	154,000 lb. per hour
Steam at 230 lb. per sq. in. is passed through a reheater and raised to	710 deg. F.

Economizer, but no air heater.

Newcastle Electric Supply Company, North Tees Power Station

Steam pressure	475 lb. per sq. in.
Steam temperature	700 deg. F.
Normal evaporation	42,000 lb. per hour
Steam at 65 lb. per sq. in. is passed through a reheater and raised to	520 deg. F.

Air heaters, but no economizers.

County of London Electric Supply Company, Barking Power Station

Steam pressure	375 lb. per sq. in.
Steam temperature	725 deg. F.
Normal evaporation	68,000 lb. per hour

Air heaters, but no economizers.

The above are typical examples and do not attempt to exhaust the high-pressure plants in use, but serve to illustrate the great modification which has occurred in design during the last ten years.

During a recent visit to America the lecturer was surprised to learn of the great number of high-steam-pressure installations in operation, and also alarmed by the fact that this great industrial country was lagging behind in enterprise.

Coming now to the question of boiler efficiency. With the modern boiler plant when maximum thermal efficiency is the main consideration, over-all figures of 86.87 per cent are attainable, but to what extent such figure is justifiable depends on the price of fuel and the load factor which the plant is required to satisfy.

The decision as to the correct steam pressure and temperature, whether economizer or air-heater, or both, should be adopted, natural draught, induced or forced draught, or a combination of either, cannot be dealt with in a few sentences. Conditions of load, capital expenditure, as also price and character of fuel, etc., all play their part; experience, however, is to be found enabling a correct decision to be made if the governing factors are known and available.

Fuel Consumption Per KW.

Although this paper is not intended to deal with the use of steam beyond the boiler stop-valve, some of you who are not actually closely connected with the producing of steam or power will be interested to learn that the modern power-stations operating with high-pressure and high-temperature steam in conjunction with modern turbine generators are producing 1 kw. for 12,800 Btu. and upwards, which is equivalent to, say, 1.17 lb. of coal per kwh., or 0.88 lb. of coal per bhp. per hour when coal of 11,000 Btu. is being utilized.

In the case of the Clyde steamer using hp. steam to which reference has been made, the observed heat rate is stated to be equivalent to 13,200 Btu. per kwh.

Many of you will be surprised that more mention has not been made of the Barton Power Station of the Manchester Corporation. The reason is that Barton was an early pioneer and the figures obtained are now well known, yet at the present date few stations in the world can surpass Barton in over-all thermal efficiency, and it is certainly the highest in the British Isles. Manchester people can congratulate the Corporation and its eminent engineers on their successful and far-seeing enterprise.

A very great change has in recent years been made in the personnel of the boiler-house. The boiler-house management is now in the control of engineers well versed in the principles of combustion, and capable of putting their knowledge to practice. Day by day efficiency is maintained close to test efficiencies, due very largely to the extended use of instruments, which, frequently checked for accuracy, have enabled the operating engineer to keep losses under observation.

Comparison of Power Plant Boilers of, Say, 25 Years Ago with Those of Today

	25 Years Ago	Today
Heating surface, largest single unit, sq. ft.	6,200	30,590
Working pressure—lb. per sq. in.	225	250-1200
Total steam temperature	550	840
Maximum rate of evaporation, lb. per hour.	30,000	300,000
K.w. capacity, say	1,500	30,000
B.h.p. equivalent, say	2,000	40,000
Boiler surface installed per maximum k.w. capacity sq. ft.	7	15

Regarding the most likely steam pressures and steam temperatures, etc., which will be adopted from the present date over the next 10 years for the power generating stations, these will most probably range from 350 to 600 lb. per sq. in. steam pressure with steam temperatures of 750 deg. F. to 800 deg. F. at the boiler end, small heating surface economizers and air heaters, the latter raising the temperature of air to the stokers to a final temperature of 250 deg. F. to 350 deg. F.

It appears, at present, unlikely that improvements in the nature of refractory materials will justify air temperatures higher than 350 deg. F. being adopted.

The 10-Inch Mill of the Colorado Fuel & Iron Company Makes Record in 1926

In 1926 the 10-in. mill broke its previous record for production. It broke a record set in 1917 when big production was the thing of the day. In 1917 the mill turned out 60,125 tons, and in 1926 it turned out 60,148 tons. But the story does not stop there with a bare topping of the previous record by 23 tons. Here is the part that will wake your imagination.

The 1917 record of 60,125 tons was rolled in 530½ 12-hour turns. The 1926 tonnage of 60,148 tons was rolled in 528¼ 8-hour turns.

No Substitute for Manganese in Steel

In the manufacture of steel, no satisfactory substitute for manganese is known, declares the United States Bureau of Mines. In Germany during the years 1917 and 1918, the shortage of manganese necessitated trial of many substitutes, such as aluminum in the forms of silicon-aluminum alloys. Aluminum has a greater affinity for oxygen than manganese, but the oxidization of alumium produces alumina which is relatively infusible and often remains in the steel as slag inclusions. Aluminum cannot eliminate sulphur or change the condition of sulphur as manganese can. A slight excess of aluminum tends to produce large pipes in the ingots. Silicon in the form of ferrosilicon probably has a greater affinity for oxygen than manganese, but its use is attended by the well known disadvantages.

Soaking Pit with Recuperator

(Continued from page 349)

making. In addition to the easier work the greater safety for the operator should be considered.

The bottom cleaning hole as well as the end cleaning door can be installed if desired.

15—*Adaptability.* The recuperator is adaptable to any number of holes or to any size hole. In France, recuperative pits are often built in batteries of 12 or 16 holes, each of which is individually controlled.

Due to the horseshoe method of firing, the recuperator can be used on any size hole by merely arranging the firing and exhaust ports where desired. If a hole for 12 or 14 ingots were desired, a recuperator could be installed at each end of the hole or two recuperators installed on one side—firing crosswise rather than lengthwise.

16—*Reduced oxidation losses.* The channeling of gases directly through the regenerative pit very frequently puts air, which has not yet mixed with the fuel, in contact with ingots, directly resulting in oxidation losses. This is noticeable with regenerative pits in which the firing port directs the flame against the side of the ingot.

With the recuperative pit, the port design is such that thorough mixing occurs before entering the pit and the burning gases travel across the pit and make a downward turn before coming in contact with the ingots thus insuring thorough mixing and complete combustion with consequent reduced oxidation.

17—*Individual Control.* Each hole is independently controlled with regard to stack, gas and air, and the condition in the hole is exactly that which the operator desires.

This is impossible with regenerative pits, since reversing takes place for the entire battery of holes at the same time, with the battery being operated as a unit.

Waste Heat Boiler Applications

(Continued from page 351)

piping and erection amounted to $28,000, or $60 per rated boiler horsepower. Since installing the boilers the furnace practice has shown a material improvement, and production has been increased 20 per cent.

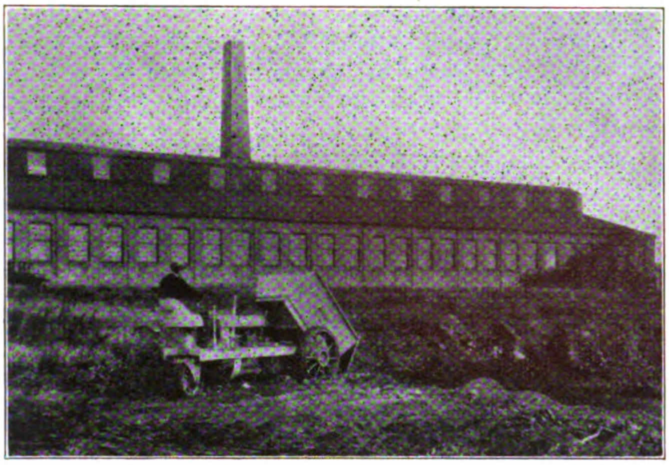
In any industrial operation wasting gases at a temperature of over 750 deg. F. it is possible to produce steam by means of waste heat boilers. Whether or not this would be an economy is a question requiring careful study of all circumstances in any particular case. As a general rule, kilns, glass tanks, oil stills, water gas sets and iron and steel heating and melting furnaces, when equipped with waste-heat boilers, will show a net return of from 25 to 100 per cent per year on the cost of equipment.

	No. 1 7 Hr. Test	No. 2 8.25 Hr. Test	No. 3 8.75 Hr. Test
Steam pressure—lb. gage	140.9	140.0	133.8
Temperatures—deg. F.—			
Gas before superheater	1,348	1,338	1,331
Gas before fan	485	490	478
Steam after superheater	495	473	484
Feedwater	175	187	184
Drafts—inches of water—			
Before superheater	0.63	0.64	0.64
Before boiler (after superh'ter)	0.91	0.91	0.91
Before fan (after boiler)	3.20	3.19	3.20
Base of stack (after fan)	0.84	0.87	0.85
Evaporation—			
Total—lb.	53,485	65,169	75,095
Average—lb. per hr.	7,641	7,899	8,582
Average CO_2 in waste gases (per cent by vol.)	9.06	8.71	8.55
Average oil consumed—gal. per hr.	152.7	155.2	160.5
Fan speed, rpm.	644	651	645
CALCULATIONS AND RESULTS			
Boiler horsepower developed—			
Total	258.0	261.8	286.5
Superheater	16.7	14.6	17.6
Boiler	241.3	247.2	268.9
Temperature of saturated steam, deg. F.	361	361	357.5
Superheat—deg. F.	134	112	126.5
Weight of waste gases—lb. per hr.	38,500	39,800	43,200
Input to fan motor—brake hp.	18.1	18.9	19.5
Rating of boiler—per cent	102.5	105.0	114.5

WITH THE EQUIPMENT MANUFACTURERS

Fordson Truck Tractor

The Wehr Company, of Milwaukee, has placed on the market the Wehr Fordson Truck Tractor for transporting materials in and around plants. The Wehr Fordson Truck Tractor has proved it can do more work for less initial and up-keep cost than any other gas, electric or horse operated vehicle used for this class of work.



1—Fordson power plant used in the Wehr Truck Tractor, has worlds of surplus power, which enables the truck tractor to perform the hardest job expected of it, with ease.

2—Every part of the unit, including the Fordson power plant, is more than twice as strong and durable as those found in miniature gas trucks and electrics now made for this class of work.

3—Service when needed is available everywhere. One or more of the 10,000 Fordson dealers always nearby. No delays waiting for parts and cost of repairs are less.

Dimensions and Weights

Wheel Base—86 in. Length overall 11 ft. 4 in. Width overall 52 in.

Turning Radius—7 ft. 4 in. Outside turning circle, 14 ft. 8 in.

Height—Ground to top of body 54 in. Ground to top of steering wheel 58 in.

Loading Space—Loading space from gas tank to end of standard frame 46 in. Width between wheels 38 in.

Bodies—Body shown is 1¼ yd., gravity dump by lever at operator's right.

A 1¼-yd. hopper type and a 2-yd. body also furnished when desired.

Weights—Truck tractor complete as shown with dump body and Fordson power plant, 4,300 lbs.

Same unit less Fordson power plant, 2,626 lbs.

Load Capacity—This unit will handle a 6,000-lb. load easily.

Speeds—Low, 1¾ to 2¼ miles per hour. Second, 3 to 4 miles per hour. High, up to 12 miles per hour.

Designed to take care of the short haulage problems of industries where short turning is essential. The Wehr Truck Tractor is of special advantage to foundries, steel plants, brick and tile factories, warehouses, coal mines and paving contractors. Several types of bodies are available for this unit; the 1-yd. dump shown; a 1-yd. hopper type, and a 1½-yd. dump as well as a 2-yd., and platform type for hauling brick, etc.

In a large iron works, not running full time, the Wehr Truck replaced eight men with a consequent saving of from $40.00 to $50.00. Besides this saving the work was done quicker thus enabling this company to save time on other work.

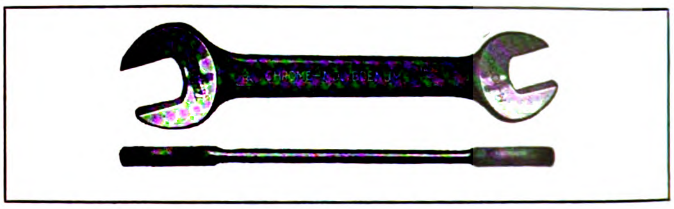
Something New in Wrenches

Some very marked advances have been made in the wrench industry during the last few months by the introduction of molybdenum—the life-time alloy—by the Billings & Spencer Company of Hartford, Conn.

Although molybdenum has long been known as semi-rare metal, it has but recently come into prominence in the field of commercial alloy steels. For some time it has been used as a fairly satisfactory substitute for tungsten in high speed steels.

The discovery of extensive deposits of the metal in Colorado—at about the time the World War created a shortage of all other alloying elements—led to further research on the effect of molybdenum in steel. It was determined that molybdenum produced much the same effect as the most prominent steel alloying elements, nickel and chromium. It was further determined that steels containing chromium and molybdenum possessed physical properties far superior to any previously known alloy steels.

As a development of the war, this new super alloy found its use in such equipment as bullet-proof armor, Baby Tanks and Liberty motors, where its extreme strength and toughness made reduction of weight possible.



Following the war, the automobile industry turned to molybdenum steel for use in many of the most severely stressed parts of motor cars.

The Billings & Spencer Company in collaboration with the leading metallurgists of the steel industry have conducted exhaustive tests and experiments on wrenches made of the various well-known commercial alloys such as chrome-nickel, nickel steel, chromevanadium, nickel-vanadium, nickel-molybdenum, chrome-molybdenum.

In these tests the chrome-molybdenum wrenches, (Billings formula) showed such consistently greater strength, hardness and toughness than the wrenches of any other alloy as to leave no doubt of the wisdom of adopting this new super alloy for our life-time wrenches.

The Billings Life-Time Wrenches are hardened and tempered by an exclusive process developed through these tests—under the most scientific heat control devices — insuring that these powerful wrenches will last a life-time.

They are designed with "spear" shaped heads for use in close or cramped quarters and the tappet wrenches are especially noteworthy in that they are designed with double spear shaped heads and are long and thin, making them very convenient in working into inaccessible places.

All of these wrenches are finished in nickel over copper plating with heads buffed, producing a beautiful and permanent rust-proof finish and, as their name implies, are guaranteed to last a life-time.

Life-time wrenches possess six times the strength of the ordinary carbon wrench, although much lighter in weight.

Electric Monorail Hoist

A motor trolley electric monorail hoist that operates in 15½ in. headroom is announced by the American Engineering Company, of Philadelphia, as an addition to its line of Lo-Head hoists.

This hoist is built in half ton and ton sizes and is similar in construction to the standard Class A Lo-Hed hoist, except that it is mounted on an 8-wheel trolley that reduces the headroom requirement by more than 5 in.

It is made for operation with a.c. at 20 fpm. or d.c. at 20 to 40 fpm. and a special high-speed hoist provides for operation at 40 fpm. with a.c. and 40 to 80 fpm. with d.c. Standard height of lift is 20 ft., but when required a lift of 25 ft. can be provided. Four ropes are used.

Remote control of both hoist and trolley motors can be provided.

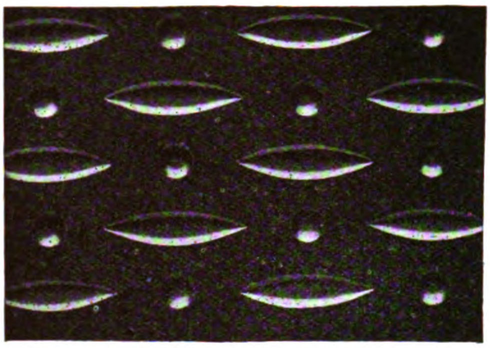
The manufacturer states that this hoist has been designed to meet the need for a means of handling and conveying materials under minimum headroom conditions and for lifting and moving bulky objects over crowded shop or warehouse floors, where clearance is at a minimum. It also permits the stacking of materials to a greater height in warehouse and factory store rooms.

This hoist travels around curves of short radius; shifts easily over switches and is protected from dust and moisture by metal covers. Motors are fully enclosed. Mechanical efficiency is over 80 per cent. Hyatt bearings are used on the gear shafts and in the trolley wheels. A ball bearing motor designed especially for hoist service is used. The drive between the motor and drum is of the spur gear type and runs in oil. Alemite lubrication is provided on all bearings not automatically lubricated by the oil bath. Holding and lowering brakes give full control of the hoist at all times and, combined with a positive acting upper limit device, insure safety in operation.

Floor Plates

More and more as time progresses, we find a closer study of floors and the material used therefore. In fact, the subject has become so important that it is the subject of discussion at many of the Safety Councils in all sections of the country.

The Central Iron & Steel Company, general offices and mills Harrisburg, Pa., manufactures a plate made from basic open-hearth steel, which serves most satisfactorily for this purpose.



Aside from the economy and the utility of this plate, it has been designed so as to add to its attractive appearance when in use.

The projections are scientifically designed so as to prevent slippage no matter from which direction it may be. Some plates have a tendency to prevent slippage in one direction but not in the other.

Again, plates of this character are found to be hard to sweep or clean. The Central design of the raised button and the diamond projection properly staggered makes the plate exceptionally easy to keep clean. The straws of the broom easily pass between all of the projections or raised parts.

These plates are made in all gauges from ⅛ in. to 2 in. thick, which allows them to be used for practically any purpose. They have been found exceptionally satisfactory for floors around machinery eliminating the usual wear as well as the dangers of slipping.

They are used for boiler room, rolling mills and open-hearth and blast furnace floors; freight station platforms and the plates from the platforms to the freight cars; gutter, conduit and manhole covers; in fact, wherever a flooring is desired.

The Central plates have been tested by the Underwriters' Laboratories and listed by them as Safety Appliance 443.

General Electric Machines Now Constructed by Welding

What promises to be a revolutionary step in the manufacture of electric machinery is the adoption of electric arc welding for the fabrication of many types of machines by the General Electric Company. This practice, as outlined in an article by R. H. Rogers in the July issue of the General Electric Review, results in many decided advantages over the use of castings.

Electric arc welding, which has recently attracted world-wide attention because of its possibilities in replacing rivets in the construction of buildings, was first tried out in the construction of electric machinery by the General Electric Company some years ago.

TRADE NOTES

The Falk Corporation of Milwaukee, Wis., manufacturers of herringbone gears, speed reducers, steel castings, Diesel engines and flexible couplings, have opened an office in Chicago at 122 South Michigan Avenue. The office will be in charge of Mr. C. H. Thomas.

* * *

The Titgen-Eastwood Company will manufacture the general line of foundry equipment heretofore made by the J. W. Paxson Company, and can also furnish repair parts for all equipment heretofore sold by J. W. Paxson Company. Offices and plant will be located at Luzerne and D Streets, Philadelphia, Pa.

* * *

Mr. W. S. Quigley, president of the Quigley Furnace Specialties Company, Inc., has announced the appointment of J. W. Marshall as advertising manager of this organization.

Mr. Marshall comes to the Quigley organization direct from the Westinghouse Electric & Mfg. Company, where he was manager of the publicity division of their Pittsburgh office. He has specialized in industrial advertising and has been connected in the past with the American Nickel Corporation, where he served as assistant sales manager, and G. P. Blackiston and staff, as manager of the creative division.

Mr. Marshall assumes his new duties with more than 15 years experience in advertising, promotion of sales, editorial and engineering experience. He is a member of the American Society of Mechanical Engineers and a graduate of Cornell University. His headquarters will be at the company's New York office, 26 Cortlandt Street.

* * *

The Whiting Corporation announce the appointment of the J. F. Shouse & Company, 1197 Starks Building, Louisville, Ky., as sales representatives, for the complete Whiting line in the state of Kentucky and the southern part of Indiana.

* * *

J. M. Brown has been added to the Pittsburgh sales force of The Surface Combustion Company and will specialize on Surface Combustion Burners for blast furnaces and Surface Combustion Burners for boilers using blast furnace or mixed gas.

Mr. Brown is a graduate of the University of Pittsburgh and a post graduate of Carnegie Institute of Technology. He has been in the metallurgical department of the Carnegie Steel Company—he has been with the Trumbull Steel Company, and with the American Heat Economy Bureau in connection with the sale and installation of automatic control equipment for open-hearth furnaces, blast furnace stoves, boilers, etc.

* * *

The C. O. Bartlett & Snow Company of Cleveland, Ohio, manufacturers of elevators, conveyors, dryers and complete handling systems for mill and factory since 1885, have just recently established a district office in Pittsburgh in order to better serve manufacturers in this district.

The new office is located at 406 Bessemer Building, Pittsburgh, Pa., and will be in the charge of Mr. W. C. Schade. Mr. Schade has a wide experience in the engineering problems peculiar to the building of special machinery for handling materials.

* * *

Sutton-Abramsen Engineering Company, Pittsburgh, has changed its name to the Sutton Engineering Company, but with no change in the personnel. The headquarters remain in the Park Building, Pittsburgh.

* * *

The contract for the brickwork construction of the two new 100-ton open-hearth furnaces at the Ashland, Ky., plant of the American Rolling Mill Company has been awarded to the Shea-Whelpley Construction Company of Cleveland, Ohio. Work to start about July 1.

The Shea-Whelpley Construction Company also are starting the construction of a by-product storage building at the coke works of the Trumbull-Cliffs Furnace Company, Warren, Ohio.

Effect of Coal Strike

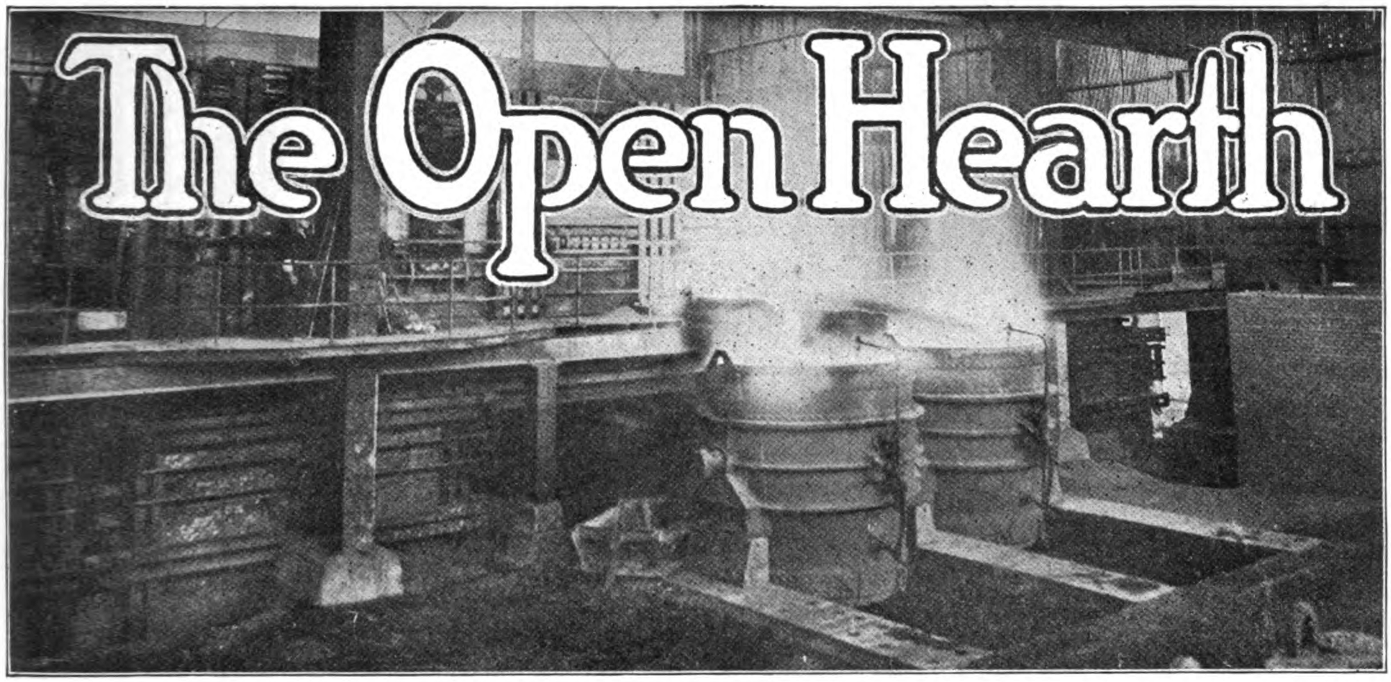
A seasonal slowing up of industrial activity is shown in the April coal consumption tonnage. The total consumption of bituminous and anthracite coal in the United States and Canada amounted to 38,600,000 tons as of May 1. The average daily consumption amounted to 1,286,666 tons. Business in general shows a gradual seasonal curtailment; no marked recessions are in evidence.

Much has been said in trade papers and in the press about coal in storage and the advisability of retaining it. That consumers evidently are heeding this advice is shown in the comparatively slight reduction of stocks on hand.

The National Association of Purchasing Agents' coal survey gives a total of 72,288,000 tons as the amount on hand as of May 1, an average day's supply for all industries of 56 days.

The effect of the strike in union bituminous fields is clearly reflected in the production figures for April. 35,775,000 tons of bituminous were produced and 7,334,000 tons of anthracite, giving a total production of 43,109,000. The April bituminous figure compared with the March production of 60,147,000 at first glance might arouse some concern. However, when the present rate of consumption is taken into consideration, and the fact that industrial activity will diminish as the summer wears on, shows clearly that the output of the non-union mines can very nearly provide for current needs.

The April production of by-product coke amounted to 3,707,000 tons, a decrease of 172,000 tons compared with the output during the preceding month. Seventy-seven active plants produced about 85 per cent of their capacity. The output of bee hive coke declined, the estimated total for the month being 780,000 tons, a decrease of 110,000 tons, or 12.4 per cent as compared with March. The output of all coke was 4,487,000 tons, of which 82.6 per cent was contributed by by-product ovens and 17.4 per cent by bee hive ovens.



The Open Hearth

T. A. Goodridge has been appointed manager of the agricultural division of the Crucible Steel Company of America, New York He will be located at the Chicago warehouse and office.

* * *

Charles R. Meissner, superintendent, Weirton Steel Company, Weirton, W. Va., has been elected president of the Eastern States Blast Furnace & Coke Oven association, with which he has been associated since its organization in 1921. Mr. Meissner is a graduate of Cornell University, Ithaca, N. Y. of 1912 and has been with Inland Steel Company, Chicago; Wheeling Steel Corporation, Wheeling, W. Va., and Koppers Company, Pittsburgh.

William A. Haven, has been elected secretary-treasurer of the association. He is superintendent of blast furnaces of The Republic Iron & Steel Company, Youngstown, Ohio. Mr. Haven was graduated from Pennsylvania State college in 1909, entering the employ of the Carnegie Steel Company, Farrell, Pa. works, soon afterward.

* * *

Gordon L. Edwards, recently elected treasurer of the United States Steel Corporation, New York, beban his business career as an office boy at the age of 15. His first job was at the New York headquarters of the National Tube Company, and in 1901, he became office boy in the treasurer's office. In 1919 he was appointed assistant to the treasurer and in 1922 he was elected assistant secretary and assistant treasurer.

* * *

W. C. Cutler has been appointed special representative of the sales department of the Bethlehem Steel Company.

Lewis R. Stuber is now in charge of the bar sales department, and John F. Hazen will handle wire nail and fence products sales. They have their offices at Bethlehem, Pa.

* * *

Guy E. Wehr, formerly superintendent of blast furnaces, for the Otis Steel Company, Cleveland, Ohio, now occupies a similar position with the Wheeling Steel Corporation, Steubenville, Ohio. At the latter works he succeeds D. B. Baird.

* * *

Mr. George J. Hagan is now connected with the Surface Combustion Company and is located in their Pittsburgh office, where he will be engaged in furthering the sales of Surface Combustion Billet Heating Furnaces and Surface Combustion equipment.

Mr. Hagan has been in the furnace business in Pittsburgh for 26 years, having founded the George J. Hagan Company, furnace contractors and builders, the Hagan Corporation, manufacturers of Hagan Control Equipment and the Hagan Foundry Corporation.

* * *

Chester W. Rice, who has been engaged in development work in the research laboratory of the General Electric Company, has been named assistant to E. W. Allen, vice president in charge of engineering. Mr. Rice will give special attention to new developments.

* * *

Benjamin Soby, assistant to manager, sales promotion department, Westinghouse Electric International Company, has been appointed manager of the advertising division, Pittsburgh district office, of the Westinghouse Electric & Mfg. Company.

* * *

Wallace Clark, member of The American Society of Mechanical Engineers, has received the Commanders Cross of the Order of Poland Restored for his services in connection with the reorganization of tobacco and salt monopolies of Poland.

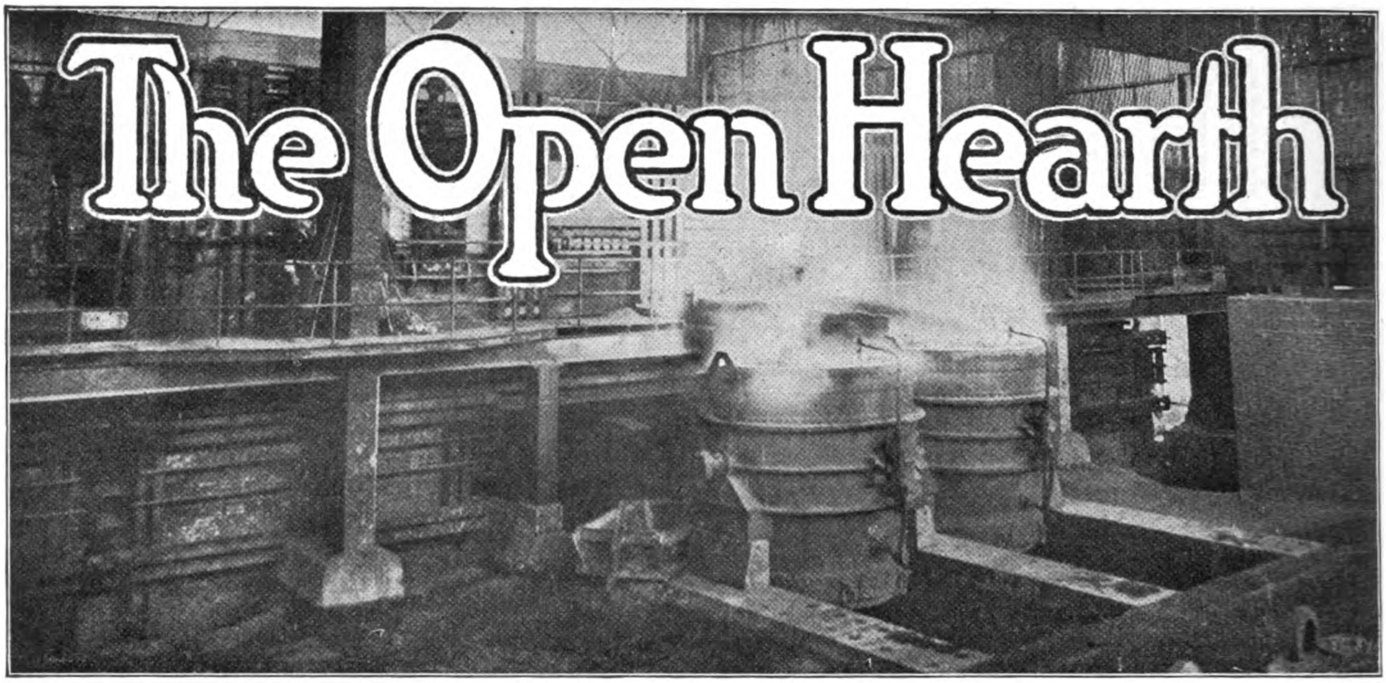
Mr. Clark was the engineer member of the Kemmerer Finance Commission which visited Poland in 1926 at the invitation of the Polish Government.

The honor was bestowed on May 13, 1927 in New York by the Polish Minister to the United States, Mr. Cieckanowski.

* * *

Mr. R. P. Shimmin has been appointed assistant to the chairman and the president of the Link-Belt

The Open Hearth



Company, and will, hereafter, make his headquarters at 910 S. Michigan Avenue.

Mr. Frank B. Caldwell has been appointed sales manager with headquarters at the Chicago plant office, 300 W. Pershing Road, and will have supervision over all sales activities in the Western division.

* * *

W. S. Moody, in general charge of the transformer engineering department of the General Electric Company since its inception, has been appointed a consulting engineer for all transformer departments of the company and for all departments of the Pittsfield works, E. W. Allen, vice president of engineering, has announced.

F. W. Peek, Jr., who has been a consulting engineer in the transformer department and in charge of the high voltage testing laboratory, has been named engineer of the general transformer department to succeed Mr. Moody.

* * *

Warren M. Heim has been appointed general manager of sales of the Oliver Iron & Steel Corporation, Pittsburgh. Mr. Heim has managed the pole line material division since early in the year, at which time he joined the company following a connection with Hubbard & Company, Pittsburgh.

* * *

J. Trautman, Jr., has been made Pacific Coast manager for the Colonial Steel Company, with headquarters at Los Angeles. He formerly was general sales manager at the main offices in Pittsburgh.

* * *

Frank T. Flynn, Steubenville, Ohio, was recently appointed manager of the new strip mills of the Weirton Steel Company, nearing completion at Weirton, W. Va. Mr. Flynn has been in charge of the old strip steel plant for many years.

* * *

George Thomas III is now treasurer of Lukens Steel Company, Coatesville, Pa. On graduation from Haverford College, Haverford, Pa., he entered the employ of the Pennsylvania Steel Company, Steelton, Pa. Later he was superintendent of the open hearth department of the Standard Steel Works, Burnham, Pa., and left there to become treasurer of the Parkesburg Iron Company, Parkesburg, Pa. Mr. Thomas is a great-grandson of Rebecca Lukens, who managed the Lukens Steel Company, in its early days.

* * *

D. A. Polhemus has been made Pittsburgh district manager of sales for the stoker department of the American Engineering Company, Philadelphia. He had recently been associated with J. B. Booth & Company, Pittsburgh, and previously was assistant to president of Pittsburgh Crucible Steel Company.

* * *

Eugene G. Grace, president Bethlehem Steel Corporation, New York, was recently honored by Lehigh University, Bethlehem, Pa., with the degree of Doctor of Science. The same degree was conferred upon William D. Coolidge, General Electric Company, and upon Elmer A. Sperry, inventor of the gyroscope stabilizer.

* * *

J. F. Schumacher until recently Chicago representative for the Continnental Bolt & Iron Works and Bourne-Fuller Company, Cleveland, is now associated with the Steel Mill Products Company, Chicago.

* * *

Donald G. Clark, has been appointed director of sales of the Firth-Sterling Steel Company, McKeesport, Pa. He has been with that company since graduating from preparatory school in 1903.

He was first employed by Edward S. Jackman, Western agent of the Firth-Sterling Steel Company, Chicago. At the October 1925 meeting of the American Iron and Steel Institute in New York he delivered a paper on "Recent Developments in Stainless Steel."

* * *

The following directors of the American Rolling Mill Company of Middletown, Ohio, have been re-elected: J. H. Frantz, S. M. Goodman, Charles R. Hook, W. S. Horner, J. M. Hutton, J. P. Orr, R. C. Phillips, F. H. Simpson, Paul Sturtevant, George M. Verity and Calvin W. Verity.

THE STEEL PLANT BRICK MASON

A Section Devoted to Items of General Interest to Blast Furnace and Steel Plant Brick Masons

Refractory Material for Extreme Conditions Developed

The Ohio Valley Mullite Refractories, Inc., has been formed to manufacture Shamva mullite refractories in the United States and Canada and to make certain other mullite refractories. This new material, which will be made in the plant of the Ohio Valley Clay Company, at Steubenville and distributed by that company, is said to withstand a test of 50 lb. per sq. in. at 1,450 deg. C. for 1½ hr. without deformation. It is also reported to have shown no spalling action after 73 continuous quenchings from 850 deg. C. into cold water and no expansion or contraction under extreme temperature variations.

Firing Refractories

Bulletin No. 271, is entitled "Problems in the Firing of Refractories." It is a very interesting publication and should be especially helpful to those desirous of obtaining information concerning the process of burning refractory brick of all varieties. The bulletin contains illustrations of practically all types of kilns and describes in much detail the procedure in firing these kilns. Temperatures obtained, heat distribution, draft, quantity of fuel burned, etc., are given for the several kilns. This Bulletin may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price is 50 cents.

William Sanderson, is superintendent of masons at the Laclede Steel Company in St. Louis. For 11 years he has been with this company, but previously had seen service in the plants of the Commonwealth Steel Company and the American Steel Foundries.

U. S. Bureau of Standards Standard Samples

Attention is called to the following United States Bureau of Standards standard samples that are either new or not as well known as they should be:

Sample number	Name	Constituents determined	Weight of sample in grams	Fee per sample
56	Phosphate rock	P_2O_5, Fe_2O_3, Al_2O_3, etc.	60	$2.00
69	Bauxite	Complete analysis	60	2.00
70	Feldspar	Complete analysis	40	2.00
71	Calcium molybdate	Mo, Fe, Ti	60	2.50
76	Burnt refractory	Complete analysis	60	2.00
77	Burnt refractory	Complete analysis	60	2.00
78	Burnt refractory	Complete analysis	60	2.00
80	Soda lime glass	Complete analysis	45	2.00

Samples may be paid for in advance with order or be sent by parcel post, C. O. D., in the United States and its possessions. All foreign shipments require prepayment together with 20 cents postage for every 300 g. of sample.

A complete list of standard samples together with analyses, fees and general directions are given in the department of commerce supplement to Circular No. 25 which can be obtained free of charge upon application to the Bureau of Standards, Washington, D. C.

Bibliographies

The Refractories Division of the American Ceramic Society, Lord Hall, Ohio State University, Columbus, Ohio, has published two bibliographies: One of silica refractories and one of magnesite refractories.

Notes on Mullite Refractories*

The general subject of mullite refractories has received a great deal of study and discussion in recent years. As a refractory this material shows considerable promise, although its application to various types of service is still in the experimental stage.

The nature of the studies and application of the minerals used to manufacture mullite refractories is more or less technical, and it is believed that a non-technical account of these materials will be of value to many interested in refractories.

The minerals of the sillimanite group are sillimanite, cyanite and andalusite, and although all three are of the same chemical composition, they are different in their physical properties. They are composed of alumina and silica (also the basic components of clays), which are present in the following proportion:

Alumina	62.9%
Silica	37.1%
	100.0

These minerals being chemical compounds, will follow the laws of chemical combination by showing a definite ratio between the molecules of alumina and silica which unite. In technical terms, it would be stated that the sillimanite minerals combine in a molecular ratio of 1:1.

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*Technical bulletin No. 7, American Refractories Institute.

The chemical symbol of one molecule of alumina is Al_2O_3 and for silica SiO_2, so a material with a ratio of 1:1 of these components may be written $Al_2O_3.SiO_2$. A compound containing three molecules or parts of alumina (Al_2O_3) combined with two molecules of silica (SiO_2) could be written $31A_2O_32SiO_2$. Such a composition is mullite and calculated to percentage is equal to

Alumina	71.8%
Silica	28.2%
	100.0

It is evident that both the sillimanite group of minerals and mullite are composed of alumina and silica, but that the percentage of each constituent is different in these minerals.

There are large deposits of the minerals of the sillimanite group, but no deposits of mullite are known except those of mineralogical interest on the Island of Mull. In fact, mullite was unknown previous to the work conducted by Bowen and Greig which was published in 1924.

Previous to the discovery of mullite is was believed that the crystals which form in minerals of the sillimanite group, when they are given the necessary heat treatment, were simply recrystallized sillimanite. For various reasons, however, the Geophysical Laboratories of the Smithsonian Institute decided to continue their studies of these crystals and other compositions of alumina and silica. This work led to the discovery that the supposed "recrystalized sillimanite" was another material possessing other characteristics than sillimanite. This new compound was named "mullite" since this mineral has been found on the Island of Mull.

Effect of Purite on Refractories

By G. S. Evans[†]

The purpose of this paper is to set forth something of the nature and importance of the present development of the use of alkalies in foundry practice and to outline briefly the effect upon refractories of purite in its various uses, as developed in regular practice at different plants. It is hoped that this will be the means of opening up a frank discussion of the subject and of creating an interest among fire brick manufacturers in the development of a lining material better suited to withstand the corrosive action of sodium alkali slags as refining baths on molten iron.

Purite is fused soda ash especially prepared in 2 lb. bricks to meet the requirements of the foundry industry. It is made by fusing the flowers of soda ash in a closed oven and casting the liquid compound into pigs, and will analyze 99 per cent sodium carbonate (Na_2CO_3). The fused brick will not absorb moisture and melts gradually when brought into contact with molten iron, which prevents any possibility of explosion or injury to operatives from flying alkali dust.

Sodium carbonate is a manufactured alkali strongly basic and very reactive chemically. It melts at 1,560 deg. F. and is decomposed at 2,240 deg. F. by molten cast iron, liberating free sodium; it also decomposes in the presence of incandescent coke. The value of soda ash as a refining agent for cast iron is due to its strongly basic properties, low fusion point and extreme activity at comparatively low temperatures.

The sodium slag attacks free silica or silicates in mud grouting quite vigorously at the temperature of cupola metal, forming sodium silicates. This action is not so pronounced upon burned brick of similar composition where the different ingredients have been sintered together, so that it is important to reduce the use of mud to a minimum. First, for the reason that it is rapidly cut out by the slag, loosening the brick and allowing them to fall out and, second, because of the action of mud in diluting or neutralizing the sodium. Generally speaking, the efficiency of the slag is inversely proportional to the percentage of silicates present.

Ladle Linings

Numerous experimental ladle linings laid up with different brands of fire brick and plastic lining materials have been under observation during the past three years without developing any outstanding results. The observation to date may be summarized as follows:

1—Linings laid up from high quality Diaspore bricks generally used in the glass industry for fusing soda glass mixtures gave less service than those from the ordinary run of fire brick.

2—Tests of several neutral materials including chrome and magnesite bricks indicated the impracticability of this type of lining.

3—Monolithic linings have not so far proven economical as compared to fire brick.

4—Little difference was noted in the life of linings laid up with clay brick of high or low silica content.

5—Dense and comparatively hard burned brick generally gave the longest service.

6—Trueness of form which permits of tight joints is of particular importance in determining the life of the lining.

Experiments are under way with gannister linings and vitrified brick which have a tendency to expand in service, thereby sealing the brick joints more tightly. However, present data is insufficient to justify any statement on the merits of either type of lining.

Malleable Iron Melting Furnaces

One of the newer uses of the alkalies in the foundry industry consists of refining air furnace malleable iron with a final slag of 5 to 15 lb. of fused soda ash per ton. Sulphur reductions of 10 to 25 per cent of that present in the bath are regularly obtained, together with some deoxidation of the metal and removal of slag inclusions—all of which combined tend to improve the annealing properties of the casting. Continued use of 10 to 12 lb. of the reagent per ton, extending over several months, have indicated that with the proper handling there is no injurious effect upon the furnace lining.

The action of alkalies in oil or gas fired brass furnace practice is, first, to increase the recovery of metal from the slag or dross, as it is called in this industry, and second, to prevent building up "niggers" or oxide-slag obstructions on the furnace lining.

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[*] Abstract from paper delivered at the spring meeting of American Refractories Institute, Atlantic City, May 18, 1927.

[†] Metallurgist, The Mathieson Alkali Works.

SAFETY FIRST IN THE STEEL PLANT

Section Devoted to the Interest of the Safety Movement

1927 National Safety Congress Program Is Now Being Arranged

That the sixteenth annual safety congress, which will be held at the new Hotel Stevens in Chicago, Sept. 26-Oct. 1, will be the largest accident prevention gathering the world has ever seen, is the opinion of officers of the National Safety Council who are now busily engaged in perfecting arrangements and preparing the program. One of the factors which is contributing much to the assured success of the coming convention is the congress program correlating committee which is assisting the various sectional program committees in harmonizing their various programs, both as to subjects and session dates, so that each program will be available to the greatest number of delegates.

The great success of the session last year devoted to a discussion of safety in the small plant has led to the planning of a much larger and even more interesting meeting this year.

$1,000 to Be Awarded Safety Poster Artists

The National Safety Council has inaugurated a poster competition for accident prevention drawings and will award $1,000 in gold as prizes in the hope of interesting artists in organized efforts to conserve lives, limbs and property. The first prize winner will receive $500; the second $300; the third, $200 and there will be ten honorable mentions. On the jury of award are Philip Lyford, atist; Burton Harrington, editor of "The Poster," and Walter G. King, president, National Safety Council. The competition, which is conducted under the technical regulations of the National Poster Art Alliance, Inc., will close November 1.

JOHN A. OARTEL
President of the Western Pennsylvania Safety Council.
Chief of Safety Bureau, Carnegie Steel Company.

The Business Facts of Safety

Fact No. 1

Accidents result from human causes and are, therefore, preventable.

Often the "cause" is so far removed from the "effect" that the accident is laid to "an act of God."

That, however, is merely shutting your eyes to the facts, for somewhere back of every accident someone was careless, neglectful or ignorant of the safe and proper way to perform a task.

Do not be satisfied with the answer that the accident was "unavoidable." Make sure that the cause did not arise from the lack of supervision on the part of someone in your employ.

Make Fourth of July Safe

Children are entitled to a safe and sane Fourth of July, avers the National Safety Council which urges parents to watch their youngsters and guide their sports away from the dangerous games that have caused accidents and fires in previous years.

Accidents in the Home

During the first four months of 1927, more people were killed right in their own residences than on the streets and highways. Unless accidents in homes are checked, the problem of safe guarding residences will become a more difficult question to solve than the task of protecting the American people, both motorists and pedestrians, while they are on the streets and highways.

Hundreds of communities, national organizations, state bodies and local associations are trying to cope with the traffic problem but practically nobody is worried about the national toll taken by home accidents. Organized safety efforts are reducing the number of accidents outside the home. Thousands of industrial shops, factories and plants and hundreds of motor clubs, safety councils, owners of motor vehicle fleets, and other bodies are holding meetings to tell people how to avoid accidents while at work and outside their workrooms, but there are no rallies or organized efforts to point to the perils that are to be found in every home.

More than 18,500 men, women and children met accidental deaths in their own homes last year. According to the National Safety Council, which is trying to prevent accidents everywhere, the same causes that are responsible for the toll taken in industry and on the streets are behind the fatality records in homes and the same preventive measures will safe guard residences. Making the home safe, however, is an individual matter in most cases. It is up to you!

—National Safety Council.

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TRADE PUBLICATIONS

The Link-Belt Company of Philadelphia, Chicago and Indianapolis have just issued a new publication entitled "Link-Belt Typical Elevators." The book consists of 44 pages of illustrations, examples, ratings, capacities and tables showing how to select typical elevators.

The elevators described in this book are applicable to average conditions for handling practically all materials in bulk.

For convenience in selecting elevators they are divided into classes, governed by the nature of the material to be handled.

Class C elevators are used for handling coal and other non-abrasive materials weighing approximately 50 lbs. per cu. ft. Class A elevators are used for handling ashes and other abrasive materials weighing about 40 lbs. per cu. ft. Class S elevators are used for handling either abrasive or non-abrasive materials weighing about 100 lbs. per cu. ft. They are recommended for heavy materials and hard service.

There are two general types of typical elevators in common use, known as the centrifugal discharge and continuous bucket types. The information given in this book will be helpful in connection with the selection of the proper elevator.

Copies can be had by addressing the Link-Belt Company, 910 S. Michigan Avenue, Chicago.

* * *

Circular 1688-B, Westinghouse Distribution and Small Power Transformers, has just been released by the publicity department of the Westinghouse Electric & Mfg. Company. This circular is particularly well made up and begins with a thorough discussion of the application of various forms of distribution and small power transformers. It continues with several pages of halftone illustrations showing the construction of the various parts. The last two pages of the circular contain some new and interesting charts depicting the application of various kinds of transformers, depending upon the kv-a. rating and the voltage classification.

Copies of this circular may be obtained from any of the district offices of the Westinghouse Company or from the publicity department at East Pittsburgh.

* * *

R. H. Beaumont Company of Philadelphia recently issued Catalog No. 95, devoted to the Beaumont Cable Drag Scraper System for handling sand, gravel, stone and other bulk materials.

Simplicity of equipment for this service has been the keynote of the catalog, while the units that make up the system are described in detail.

The driving drums, or scraper hoists, both band and cone friction, are described in the electric, gasoline and belt drive types.

The many illustrations show interesting installations and applications of the equipment.

Beaumont Bin Gates are given a prominent place in the catalog which also features the newly acquired Beaumont American Slack Line Cableway.

* * *

The Bartlett-Hayward Company present a catalogue describing Fast's Flexible Coupling which is manufactured by them. The catalogue contains coupling data and information of value to coupling users and engineers. A copy may be obtained by request to the Bartlett-Hayward Company, Scott and McHenry Streets, Baltimore, Md.

* * *

The Bailey Meter Company of Cleveland, Ohio, has just issued a 24-page bulletin No. 131 descriptive of a new line of electrically-operated fluid meters which may be used to indicate, record and integrate the flow of steam, water, air, gas and other fluids. Due to the electrical principle of operation, the indicating, recording and integrating instruments can be arranged in any combination, or located at any distance from the pipe line in which the flow is being measured. These meters have been designed so they are unaffected by ordinary voltage variations, and consequently do not require the use of voltage regulators to maintain a constant voltage. The bulletin contains a number of illustrations showing applications of these meters for measuring the steam consumption of machines, processes, etc.

* * *

Warren Webster & Company, are mailing Bulletin 103 which contains a description of "Webster Feed-Water Heaters of Genuine Puddled Wrought Iron." The construction of the heater is explained in detail together with its operation. About 1 per cent of fuel is saved for every 11 deg. the water is raised in temperature. The bulletin is somewhat of a text book on feed water heating.

* * *

"Worm Gears and Drives" is the subject of Bulletin E published by the Fawcus Machine Company of Pittsburgh, Pa. Space is devoted to an explanation of the construction and application of the Fawcus-Timken Bearing Worm Drive manufactured by the company. A section contains data for the use of engineers.

* * *

The "Caldwell Speed Reducer" has been placed on the market by the H. W. Caldwell & Son Company, Chicago. It is described in Book No. 630, Type "A" is for general industrial service and type "B" is a special design for driving screw conveyors. Information relating to the application of these reducers is given along with prices, etc.

* * *

"Inundation" for the central mixing plants is the title of an attractive pamphlet edited by the Blaw-Knox Company of Pittsburgh, Pa. Illustrations show the manner of operating the system for the mechanical control of water—cement ratio and production of constant concrete inundation is employed for all manner of construction in both large and small jobs. The pamphlet explains the degree of accuracy which can be obtained in mixing concrete. For the small job the Junior Inundator is recommended.

* * *

"Clean Dry Steam—How to Secure It," appears on the cover of a booklet recently issued by the Hagan Corporation, Bowman Building, Pittsburgh, Pa. It contains some valuable and useful information for users of steam.

This booklet discusses the importance of clean dry steam and the requirements exacted of steam separators by present day boiler practice.

The three-stage centrifugal operation of the Hagan Steam Separator is explained and helpful data is given relative to application, installation, testing, etc.

NEWS OF THE PLANTS

The Milwaukee Blast Furnace Company, Milwaukee, Wis., has been incorporated to manufacture pig iron and its by-products. It is incorporated by a syndicate of bondholders of the defunct Thomas Furnace Company, Milwaukee, for whom the Thomas property recently was bid in for $300,000 by S. G. Garraway, of the S. G. Garraway Company, Chicago, who is expected to be elected president of the new corporation. David W. Bloodgood, attorney, 85 East Michigan Street, Milwaukee, is secretary of the bondholders committee and with several attorneys appears as incorporator.

* * *

The Kokomo Steel & Wire Company, Kokomo, Ind., authorizes the announcement that the required number of stockholders of the three companies that are being merged into the Continental Steel Corporation have given their approval of the consolidation. The other companies are the Superior Sheet Steel Company, Canton, Ohio, and the Chapman-Price Steel Company, Indianapolis.

* * *

The blast furnace of the Clinton Iron & Steel Company, Pittsburgh, the only merchant stack in Pittsburgh and the oldest in the Pittsburgh district, will discontinue operations. This Clinton furnace was built in 1851 and rebuilt in 1914. Its stack dimensions are 78 ft. x 18 ft., and its annual capacity, 110,000 gross tons. The American Iron & Steel Association's directory of 1875 listed it as owned by Graff, Bennett & Company, the stack dimensions as 45 ft. x 12 ft. and the annual capacity as 12,000 net tons.

* * *

The St. Louis Coke & Iron Corporation, Granite City, Ill., is proceeding with plans to enter the market as steel producers. The plans call for the building of four 100-ton open-hearth furnaces and a billet mill. The finished product is to be seamless pipe, for the production of which a mill that will make pipe up to 22 in. in diameter is contemplated. The by-product coke plant will be enlarged by the addition of 40 ovens.

* * *

Announcement is made that a group of Lancaster, N. Y. business men, comprising the Lancaster Malleables & Steel Corporation, has purchased the Lancaster plant of the American Malleables Company. The plant has been idle since New Year's day when the finishing department burned. Work has been started on the new finishing department and it is hoped to complete this in time to begin operations in July.

* * *

Incorporation of the Pittsburgh Screw & Bolt Corporation combines under one head with change of personnel the Pittsburgh Screw & Bolt Company, Pittsburgh, and the Gary, Ind., and Continental (Chicago) works of the Gary Screw & Bolt Company. The new corporation is issuing $5,000,000 20-year 5½ per cent debenture bonds.

One of the two Hubbard stacks of the Youngstown Sheet & Tube Company resumed, June 1, after several months of idleness during which time improvements have been made. When the new plant of the Valley Mould & Iron Company is completed on adjacent plot, about July 15, the Hubbard furnaces will furnish the hot metal.

* * *

In 1923 the Columbia Steel Corporation undertook the production of iron and coke from Utah coals and iron ore, building for this purpose a blast furnace and by-product coke plant at Provo, Utah. The growth of their business has now made it necessary for them to enlarge their plant.

To obtain additional coke, the Columbia Steel Corporation has contracted with the Koppers Construction Company for an addition to its by-product coke plant to consist of 23 Becker Type Ovens and added by-product and benzol capacity.

With this addition, Columbia will have 56 Becker Type Ovens with a total annual carbonizing capacity of approximately 600,000 tons of coal.

General Guy E. Tripp Dead

Brigadier General Guy E. Tripp, chairman of the board of directors, Westinghouse Electric & Mfg. Company, died at 6:55 o'clock Tuesday evening, June 14, in the New York hospital, New York.

His death was due to complications following an operation.

Guy Eastman Tripp was born in Wells, Maine, April 22, 1865, a son of Alonzo K. and Abbie F. (Yeston) Tripp.

He was educated at South Berwick (Maine) Academy, and at the age of 18 entered the employ of the Eastern Railway Company.

In 1890 he became storekeeper for the Thompson-Houston Electric Company, which was under contract for the electrification of the West End Railway of Boston.

In 1897 he became associated with Stone & Webster, construction engineers and operators of public utilities, occupying successively important positions until he was elected vice president of the Stone & Webster Management Association and also of the Stone & Webster Engineering Corporation.

He was selected for the position of chairman of the Board of Directors of the Westinghouse Electric & Mfg. Company, assuming his duties in the latter position as of February 10, 1912, in which capacity he has continued to date (1927). Mr. Tripp brought to this company the sound financial judgment that was its greatest need.

A Prepared List of Books on Steel Plant Practice and Allied Subjects

Metallurgy of Steel

Harbourd and Hall

Vol. I. Seventh edition, thoroughly revised, 200 illustrations, 577 pages, 8vo., cloth. $12.00.

CONTENTS—The Manufacture of Steel—The Bessemer Process; The Basic Process; Manufacture of Steel in Small Converters; Chemistry of the Acid Bessemer Process; Chemistry of the Basic Bessemer Process; Gas Producers; The Open Hearth or Siemens Process; Basic Siemens Process; The Production of Steel Castings; The Production of Shear and Crucible Steel; Production of Steel in the Electric Furnace; Armor Plate Manufacture; Direct Processes of Steel Manufacture. Finished Steel—Mechanical Testing of Materials; Carbon and Iron; The Influence of Si, S, P, Mn, As, Cu, Sn, Sb, etc., on the Physical Properties of Steel; Special Steels or Steel Alloys; Heat Treatment of Steel; Microscopical Examinations of Steel; Typical Steel Plants; Photomicrographs. Appendices.

The Metallography and Heat-Treatment of Iron and Steel

Sauveur

By Albert Sauveur, Gordon McKay Professor of Metallurgy and Metallography in Harvard University. 535 pages, 7x10, 463 illustrations. $8.00.

The standard treatise on the subject. It presents in a scientific and practical manner a well-balanced, specific and comprehensive treatment, covering the structure of metals, the processes, manipulation and apparatus used successfully in the author's own laboratory and in the laboratories of other workers.

The present edition includes descriptions and discussions of the notable advances in metallography during the last decade. Every chapter has been revised and enlarged and several practically rewritten. Much new material has been added as well as some 125 illustrations. M

Analysis of Fuel, Gas, Water and Lubricants

Parr

By S. W. Parr, Professor of Applied Chemistry, Universty of Illinois. International Chemical Series. Third edition. 250 pages, 5½x8, 54 illustrations. $2.50.

CONTENTS—Part I, Lectures. Fuels; Coal; Sampling of Coal; Analysis of Coal; Unit Coal; Calorimetric Measurements; Ultimate Analysis; Classification of Coals; Coal Contracts; Combustion of Coal; Storage, Weathering and Spontaneous Combustion; Coke; Wood; Petroleum, Distillates and Alcohol; Fuel Gas; Flue Gases; Boiler Water; Lubricants. Part II, Laboratory Methods. Proximate Analysis of Coal; Calorimeter, Using Sodium Peroxide; Calorimeter, Using the Oxygen Bomb; Sulphur Determinations; Ultimate Analysis; Fuel Gases Analysis; Analysis of Flue Gases; Analysis of Boiler Waters; Oil Examination. M

Strength of Materials

Poorman

313 pages, 6x9, 211 illustrations. $3.00. In this new book Professor Poorman's ability to appreciate the student's difficulties and to simplify and clarify the explanations of abstruse points is again apparent. Throughout the work a large number of illustrative examples have been worked out in detail to aid the student in mastering the relation between theory and application. The book offers a well-balanced, vigorous text.

CONTENTS—Elastic Stresses and Deformations; Tension and Compression; Ultimate Stresses and Deformations: Tension and Compression; Shearing Stresses and Deformations; Riveted Joints; Shear and Moment in Beams; Stresses in Beams; Deflection of Cantilever and Simple Beams; Fixed and Continuous Beams; Beams of Constant Strength; Beams of Two Materials; Resilience in Beams; Torsion of Shafts; Combined Stresses; Suler's Column Formula; Rankin's Column Formula; Straight Line Column Formula; Column in General; Deflection of Beams by Area Moment Method; Deflection of Beams by Equivalent Cantilever Method; Curved Beams and Hooks.

Standard Handbook for Electrical Engineers

Fowle

Editor-in-chief, Frank F. Fowle, Consulting Engineer, assisted by a staff of more than 60 specialists. Fifth edition, completely revised and enlarged. Total issue, 88,500. 2100 pages, 4½x7, flexible, thumb-indexed, illustrated. $6.00.

The widely known encyclopedia of electrical engineering is thoroughly revised to embody the latest developments and data. Some of the sections have been entirely rewritten. All have been brought strictly up to date. The book covers every branch of modern electrical engineering. It is complete and reliable, and so carefully and fully indexed that its information is readily accessible. M

Materials Testings—Theory and Practice

Cowdrey and Adams

By Irving H. Cowdrey, Assistant Professor of Testing Materials, and Ralph G. Adams, Instructor in Mechanical Engineering, Massachusetts Institute of Technology. 129 pages, 6x9, 51 illustrations, cloth. $1.50.

This book gives a concise presentation of the methods and the fundamental theory of the testing of materials of construction, with condensed specifications and properties of the more common ones. A study of the test will lead to a clearer understanding of specifications, and will be of assistance in the interpretation of the results of physical tests.

CONTENTS—Province of the Testing Engineer. The Report. Testing Machines. Tensile Tests. Graphs. Compressive Tests. Torsional Tests. Transverse Tests. Dynamic Tests. Test Specimens and Holders. Fractures and Their Significance. Hardness Determination. Cement Testing. Testing of Sand. Timber Testing. Measuring Devices. Verification of Testing Machines. Appendix.

Microscopic Analysis of Metals

Osmond and Stead

Third edition, revised and corrected by L. P. Sidney. 313 pages, 8vo., cloth. $4.50.

The new edition of this extremely valuable book is now in preparation and comprises features which render it thoroughly up to date in every respect. It is very beautifully illustrated with 195 photomicrographs, diagrams and figures and covers such important subjects as Anatomical Metallography, Biological Metallography, and Pathological Metallography, also the Science of Polishing, Grinding, etc., the Micrographic Analysis of Carbon Steels, the Micrographic Identification of the Primary Constituents of Carbon Steels, the Detailed Examination of Selected Steels, the Segregation in Steel and the Phenomena of Burning, Overheating, etc.

Industrial Furnaces—Principles and Furnace Calculations

Trinks

By W. Trinks, M.E., Consulting Engineer, Professor of Mechanical Engineering, Head of Department of Mechanical Engineering, Carnegie Institute of Technology. Vol. I. 319 pages, 6x9, 255 figures. Cloth, $4.50.

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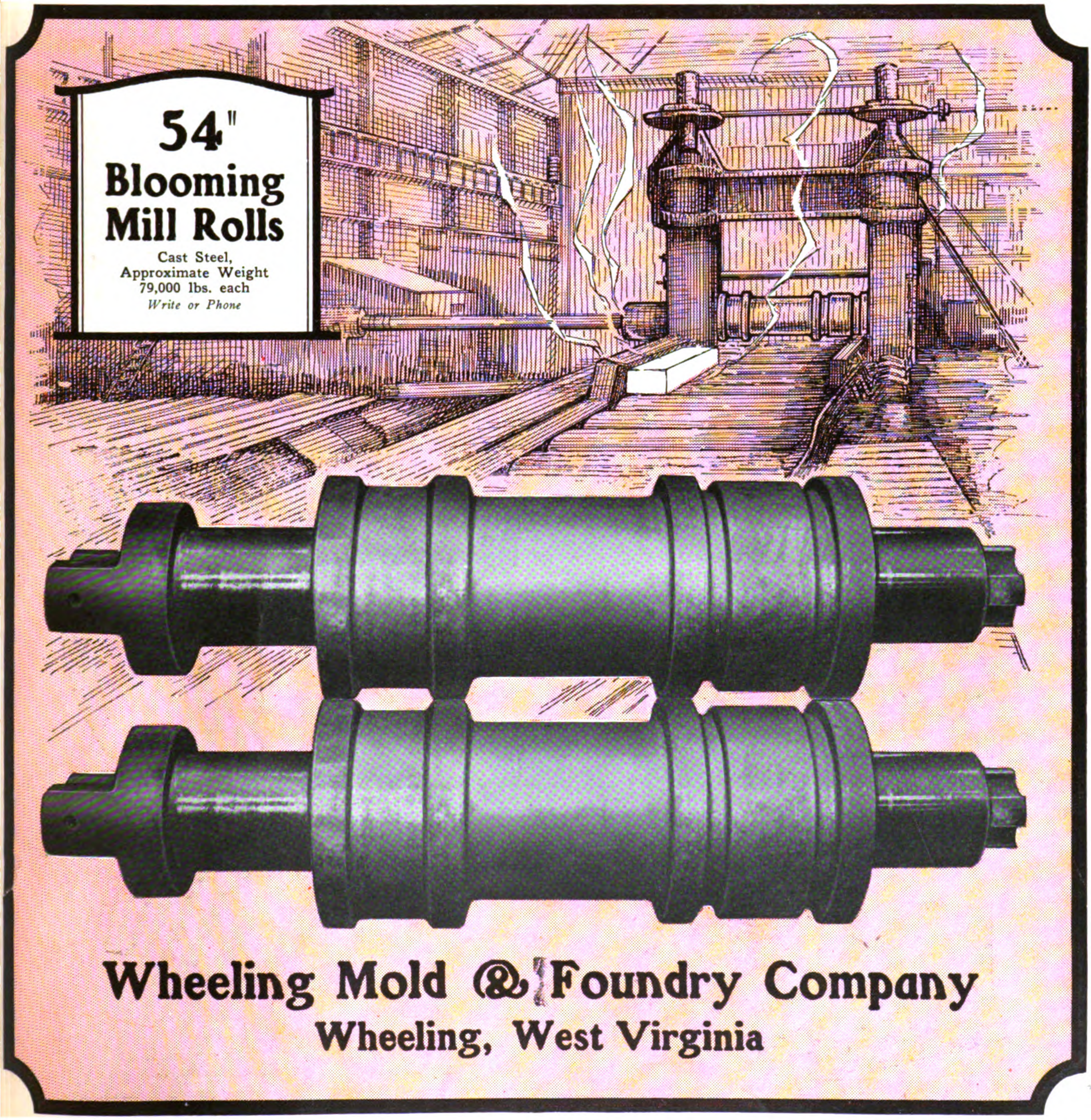

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